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A MONOGRAPH

OF THE

BRITISH DESMIDIACEÆ

BY

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BRITISH DESMIDIACEÆ.

225. **Cosmarium Botrytis** Menegh.

(Pl. XCVI, figs. 1, 2, 5–15.)

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Euastrum interstitiale Kütz. Phycol. germ. 1845, p. 136. [=*C. Botrytis* according to Kützing in Ralfs' Brit. Desm. 1848, p. xix.]

Cosmarium Botrytis var. *interstitiale* Kütz. Spec. Alg. 1849, p. 175.
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Cells above medium size, about $1\frac{1}{4}$–$1\frac{1}{3}$ times as long as broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells ovate-pyramidate from a broad, flat base, basal angles rounded, sides convex, apex rather narrowly truncate or subtruncate, apical angles rounded. Side view of semicell broadly elliptic. Vertical view elliptic, ratio of axes about 1 : 1·8. Cell-wall uniformly granulate, granules somewhat small and generally without any definite disposition (sometimes with a slight indication of a concentric arrangement or even a disposition in decussating oblique series), about 30–36 visible at the margin of the semicell. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore globose, furnished with short, stout processes, 3 (rarely 4)-fid at the apices, and generally arising from broad, expanded bases.

Length 65–90 μ; breadth 51–68 μ; breadth of isthmus 17–24 μ; thickness 33–40 μ; diam. zygosp. without processes 54–66 μ, with processes 69–84 μ.

England.—Cumberland! Westmoreland! (*Ralfs*). Lancashire! W., N., and E. Yorks. (zygospores from Markington and Pilmoor)! Cheshire (*Roy*). Leicestershire (*Roy*). Lincolnshire! Norfolk! Suffolk! Essex! (*Ralfs*). Cambridgeshire! Warwickshire! (*Wills*). Worcestershire! Gloucester! (*Ralfs*). Middlesex (zygospores from Harefield)! Surrey (zygospores from Frensham Great Pond)! Sussex (*Ralfs*). Kent! Hants! Wilts! Devon! (*Bennett*). Cornwall! (*Ralfs*). Not uncommon in the plankton!

Wales.—General! Frequent in the plankton!

Scotland.—General! Zygospores from Loch Kin-

ellan, Ross (*Roy & Bissett*). Orkneys! Shetlands! Lewis, Harris, N. and S. Uist, Outer Hebrides! Common in the plankton!

IRELAND.—Common! Plankton of the lakes of Mayo, Galway, and Kerry!

Geogr. Distribution.—France. Belgium. Germany. Austria and Galicia. Roumania. Bosnia. Hungary. Italy. Portugal. Norway. Sweden. Denmark. Bornholm. Finland. Poland. N. and S. Russia. Faeroes. Iceland. Nova Zembla. Spitzbergen. Greenland. Siberia. Mongolia. China. Japan. Afghanistan (var.). Ceylon. Burma (var.). New Zealand. Azores. United States. Brazil. Argentina. Patagonia.

C. Botrytis is the most generally distributed species of the genus in the British Islands, and possibly in the whole of Europe. It is found in all kinds of situations from stagnant bogs to well-aerated, dripping rocks, but occurs most abundantly at the margins of pools and lakes. It is not uncommon in the freshwater plankton, and in small pools it is frequently found with zygospores. The granulation of the cell-wall is of a uniform character, and the granules as a rule have no definite disposition. The form of the semicell is somewhat variable, but it is always distinctly pyramidate, with convex sides, and an apex which is more or less truncate.

Within the arctic circle the species is often rather diminutive, and Boldt records specimens from Greenland with a length of only 49·2 μ and a breadth of 43·2 μ.

Being such a cosmopolitan species, *C. Botrytis* exhibits a considerable amount of variability, and in consequence of this it has been overloaded with named varieties. We have attempted to clearly draw up the characters of about seven of these varieties, which have been discovered in various parts of the British Islands.

The development of the zygospore is better known in *C. Botrytis* than in any other species of the tribe Cosmarieæ. It was worked out by De Bary in 1858 (Consult Vol. I, p. 11, and this volume, Pl. XCVI, figs. 7–15).

Wille ('Ferskv. Alg. Nov. Semlj.' 1879, p. 35) has described a "forma *obliqua*," in which one side of the vertical view is flat and the other almost semicircular: length 63 μ; breadth 46 μ. Both semicells were apparently deformed, their outline in front view being somewhat irregular.

C. Botrytis var. *afghanicum* Schaarschm. ('Afghan. Alg.' 1884, p. 245, t. 5, f. 19) is not a form of *C. Botrytis*.

Var. **paxillosporum** *var. nov.* (Pl. XCVI, figs. 3, 4.)

Cell-wall minutely punctate between the granules. Zygospore furnished with short, blunt spines, each of which arises from the apex of a mamillate or bluntly conical projection.

Length 72–80 μ; breadth 57–61 μ; thickness 29–36 μ; diam. zygosp. without spines 42–56 μ, with spines 60–72 μ.

England.—Yorkshire! Surrey (zygospores from Frensham Great Pond, and from pond east of Chapel Wood)! Cornwall!

Scotland.—Sutherland! Near Kirkwall, Orkneys!

The vegetative cells of this variety differ only in the presence of distinct punctulations between the granules, but the zygospore differs markedly from that of typical *C. Botrytis* in the blunt spines which arise from conspicuously swollen bases. The spines of the mature zygospores remain bluntly rounded with no trace of apical denticulations.

Var. **subtumidum** Wittr. (Pl. XCVII, fig. 1.)

C. Botrytis var. *subtumidum* Wittr. Gotl. Öl. sötv. Alg. 1872, p. 57, t. 4, f. 12; Boldt, Desm. Grönland, 1888, p. 28; Andersson, Sverig. Chlor. 1890, p. 14; Schmidle, Chlorophy.-Fl. Torfstiche Virnheim, 1894, p. 58; Roy & Biss. Scott. Desm. 1894, p. 44; Borge, Beiträge Alg. Schweden, 1906, p. 30.

Cells rather wider than in the type, basal angles more projecting, slightly tumid in the centre of the semicells, and with the granules covering the tumour somewhat larger than the rest of the granules.

Length 52–80 μ; breadth 43–65 μ; breadth of isthmus 10–15 μ; thickness 28–38·4 μ.

Scotland.—Aberdeen, Kincardine, Perth (*Roy & Bissett*).

Geogr. Distribution.—Germany. Galicia in Austria. Sweden. N. Russia. Greenland. Siberia.

This variety must be exceedingly rare, and we have never seen any form of *C. Botrytis* that we could with justice refer to it.

Var. **tumidum** Wolle. (Pl. XCVII, figs. 2, 3.)

C. Botrytis var. *tumidum* Wolle, Desm. U. S. 1884, p. 75, t. 17, f. 3-5 [figures not accurate]; Schmidle in Ber. Deutsch. Botan. Ges. x, 1892, p. 210, t. 11, f. 13–14; Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 99, t. 4, f. 25 [figure not good]; West & G. S. West, Alg. S. England, 1897, p. 490; Freshw. Alg. Orkneys and Shetlands, 1905, p. 21; Further Contrib. Plankton Scott. Lochs, 1905, p. 484.
C. Subbotrytis Schmidle, Alg. Bern. Alp. 1894, p. 93.

Semicells with central tumour causing an inflation on each side of the vertical view; granules of the central tumour larger than the other granules, and with a very irregular disposition; often with one large granule adjacent to the isthmus.

Zygospore exactly as in the type.

Length 65–85 μ; breadth 50–68 μ; breadth of isthmus 17–20 μ; thickness 34–38 μ.

England.—Epping Forest, Essex! Near Goring, Oxfordshire (with zygospores)!

Scotland.—Inverness! Lewis, Outer Hebrides! Shetlands! Plankton of Loch Shiel, L. Cuthaig!

Geogr. Distribution.—Germany. Australia. United States.

We see no justification for the separation of this variety as a species distinct from *C. Botrytis*. It differs from the type only in the slight central tumour adorned with granules of a rather larger size than the other granules of the cell-wall.

Var. **gemmiferum** (Bréb.) Nordst. (Pl. XCVII, fig. 4.)

Cosmarium gemmiferum Bréb. Liste Desm. 1856, p. 301; Arch. in Pritch. Infus. 1861, p. 733; Rabenh. Flor. Europ. Alg. 1868, III, p. 159; Lund. Desm. Suec. 1871, p. 26; Nordst. in Wittr. & Nordst. Alg. Exsic. 1886, no. 826; De Toni, Syll. Alg. 1889, p. 985.
C. Botrytis var. *gemmiferum* (Bréb.) Nordst. Bornh. Desm. 1888, p. 191; Gutw. Flor. Glonow Okolic Lwowa, 1891, p. 52.
Ursinella gemmifera Kuntze, Revis. gen. plant. 1891, p. 924.

Semicells with a central granulated tumour surrounded by a smooth area of small extent, towards which the surrounding granules are slightly reduced in size; vertical view with a small inflation on each side.

Length 65–89 μ; breadth 55–72 μ; breadth of isthmus 14–24 μ; thickness 35–48 μ.

England.—Enbridge Lake, Hants (*Roy*). Sutton Park, Warwickshire!

Scotland.—Loch Kinellan and Falls of Connon, Ross; Loch Ruthven, Inverness; near Alford and Cambus O'May, Aberdeen; Fife (*Roy & Bissett*).

Geogr. Distribution.—France. Galicia in Austria. Sweden. Bornholm. Finland.

This variety differs from var. *tumidum* Wolle chiefly in the clear space surrounding the central granulated tumour.

Var. **emarginatum** Hansg. (Pl. CIII, fig. 8.)

C. Botrytis var. *emarginatum* Hansg. Prodr. Algenfl. Böhm. 1888, p. 199 (c. fig. 116); Roy & Biss. Scott. Desm. 1894, p. 44; Nordst. in Wittr. & Nordst. Alg. Exsic. 1903, no. 1479; fasc. 35, p. 13 'forma'; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 179.

Semicells with a blunt notch (about 3 μ deep) in the middle of the apex, causing an apical emargination; granules rather larger than in the type, but other characters and dimensions are the same.

England.—Brent Reservoir, and in ditches at Kingsbury Green, Middlesex! Enbridge Lake, Hants (*Roy*). Near Trimpley, Worcestershire!

Scotland.—Not uncommon on wet rocks (*Roy & Bissett*).

Geogr. Distribution.—Germany. Galicia and Bohemia in Austria. Roumania. Sweden.

Var. **mediolæve** West. (Pl. XCVII, fig. 5.)

C. Botrytis var. *mediolæve* West, Alg. W. Ireland, 1892, p. 155, t. 21, f. 12; West & G. S. West, Alg. S. England, 1897, p. 490; G. S. West, Alga-fl. Cumbr. 1899, p. 218; West & G. S. West, Alga-fl. Yorks. 1900, p. 83; Schmidle in Summer's Kryptogamenfl. der Kreuzeckgr. Kärnten, 1901, p. 101; West & G. S. West, Alg. N. Ireland, 1902, p. 39.

C. schochthodes Schmidle, Weit. Beitr. Algenfl. Rheineb. u. Schwarzwald. 1895, p. 75 (in part), fig. 27 *a* and *b* (not fig. 26 *a–c* (= *C. cymatopleurum* var. *lævidiscum*)); Schröder, Beitr. Algen Reisengebirges, 1898, p. 35, t. 1, f. 11 (?).

Semicells with a smooth and faintly concave apex; granules arranged in radiating and concentric series, gradually becoming smaller towards the centre of the semicell which is quite smooth. Sides of vertical view subparallel in the middle, and smooth.

Length 65–70 μ; breadth 55–59 μ; breadth of isthmus 15 μ; thickness 25–27 μ.

England.—Near Ingleton, W. Yorks! Strensall Common, N. Yorks! Near Brigg, Lincolnshire! Lord's Bridge, Cambridgeshire! Esher West-end Common, Surrey! Hayes Common, Kent!

Ireland.—Churchill, Donegal! Near Westport, Mayo! Nacoogarrow Lough, and between Clifden and Roundstone, Galway! Clogerheen, Kerry!

Geogr. Distribution.—Germany.

This variety should be compared with *C. Botrytis* var. *mesoleium* Nordst. ('Desm. Ital.' 1876, p. 27, t. 12, f. 2), from which it is distinguished by its proportionately wider semicells, by the absence of the small central protuberance, and by the absence of the granules above the isthmus.

Var. **depressum** W. & G. S. West. (Pl. XCVII, fig. 6.)

C. Botrytis var. *depressum* W. & G. S. West, Further Contrib. Plankton Scott. Lochs, 1905, p. 500, t. 7, f. 1; Comp. Study Plankton Irish Lakes, 1906, p. 85.

Cells shorter than in the type, about as long as broad; semicells depressed, basal part very wide and basal angles very broadly rounded, apical angles very obtuse.

Length 68–72 μ; breadth 65–68 μ; breadth of isthmus 16–17 μ.

Scotland.—Plankton of Loch Ruar, Sutherland!

Ireland.—Plankton of Lough Corrib, Galway; and of Lough Caragh, Kerry!

We have only met with this depressed variety in the plankton.

It is possible that *C. Hyacinthi* Gutw. ('Flor. Glon. Okolic Lwowa,' 1891, p. 62, t. 2, f. 30) is closely related to this variety, but Gutwinski's figure is not very good. The only distinction appears to be the presence of a central tumour in the Galician form.

226. **Cosmarium Gayanum** De Toni. (Pl. CIII, figs. 5, 6.)

Euastrum (*Cosmarium*) *ellipticum* Gay, Mon. loc. Conj. Montpellier, 1884, p. 63, t. 2, f. 5 [not *C. ellipticum* Delp., 1877]; Note Conj. du midi de France, 1884, p. 337.

Cosmarium Gayanum De Toni, Syll. Alg. 1889 (July), p. 994; Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 53; Flor. Glon. Okolic Tarnapola, 1894, p. 94.
C. Gayii Gutw. Wahr. d. Priorität, 1890, p. 69.
Ursinella Gayanum Kuntze, Revis. gen. plant. 1891, p. 924.

Cells large, in general outline elliptic, about $1\frac{1}{2}$ times as long as broad, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells ovate-pyramidate from a flat base, basal angles subrectangular but obtuse, sides convex, in the upper part rather rapidly converging to the somewhat narrow and subtruncate apex. Side view of semicell elliptic. Vertical view elliptic, ratio of axes about 1 : 1·6. Cell-wall finely granulate, granules arranged in radiating and subconcentric series, about 12 visible on each lateral margin and 4 at the apex. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore globose, furnished with numerous, short, rather stout processes (about 21 visible around the periphery); apex of each process 2–3-denticulate.

Length 70–90 μ; breadth 48–64 μ; breadth of isthmus 16–19 μ; thickness 30–36 μ; diam. zygosp. without processes 60 μ, with processes 95 μ.

Geogr. Distribution.—France. Galicia in Austria.

C. Gayanum is almost of the same outward form as *C. pyramidatum*, but is at once distinguished by its granulate cell-wall. The granules are very small and disposed in a very characteristic manner. The typical form has not been observed in the British Islands.

Var. **eboracense** *nob.* (Pl. XCIII, figs. 6–8.)

C. eboracense West, Alg. N. Yorks. 1889 (October), p. 292, t. 291, f. 4; Alg. W. Ireland, 1892, p. 155; Roy & Biss. Scott. Desm. 1894, p. 100; West & G. S. West, Alga-fl. Yorks. 1900, p. 82.

Granulation of semicells denser, granules more numerous (19–23 visible on each lateral margin); apex obscurely 4–6 granulate, rarely smooth and very faintly concave; granules in the centre of the semicells considerably reduced.

Length 90·5–110 μ; breadth 55–68 μ; breadth of isthmus 20–22 μ; thickness 39–41 μ.

England.—Baildon, Arncliffe, and near Cray Moss, W. Yorks! Cronkley Fell and Staindale, N. Yorks! Richmond Park, Surrey!

Scotland.—Craig-an-Lochan, Perth!

Ireland.—Cloonee Lough and Kenmare, Kerry!

This variety differs in the denseness of its granulation, and in the reduction of the granules in the centre of the semicells.

227. **Cosmarium controversum** West.

(Pl. XCVII, figs. 7 and 8.)

Cosmarium controversum West, Alg. N. Wales, 1890, p. 289, t. 6, f. 31 figure incorrect; Nordst. Index Desm. 1896, p. 81; West & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Brit. Freshw. Phytoplankton, 1909, p. 179; Phytoplankton Engl. Lake District, 1909, p. 287.

Cells fairly large, from $1\frac{1}{5}$ to $1\frac{1}{4}$ times as long as broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells pyramidate-trapeziform, basal angles rounded, sides very slightly convex, apical angles rounded, apex broadly truncate. Side view of semicell ovate-elliptic. Vertical view elliptic, with a rather small tumour at the middle on each side. Cell-wall granulate, granules rounded, of uniform size, arranged in decussating oblique series and in indistinct vertical series, about 14 oblique series and 18–19 indistinct vertical series (sometimes not at all evident), and from 30–35 granules visible at the margin of a semicell; with a large area in the centre of the semicell in which there are hexagons of conspicuous, rounded scrobiculations between the granules. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 90–96 μ; breadth 72–77 μ; breadth of isthmus 22–32 μ; thickness 45 μ.

England.—Plankton of Grasmere, Westmoreland!

Wales.—Capel Curig, Carnarvonshire!

Scotland.—Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

The original figure of this Desmid represented the species very indifferently, and the large, scrobiculated central area

was quite omitted. This scrobiculated area occupies the whole of the central tumour and the adjacent parts of the cell-wall.

It is distinguished from *C. Botrytis* by the broader apices of the semicells, by the larger and regularly arranged granules, and by the tumid and scrobiculated central area of the semicells.

228. **Cosmarium ochthodes** Nordst.

(Pl. XCVIII, figs. 1–3.)

Cosmarium ochthodes Nordst. Desm. Arctoæ, 1875, p. 17, t. 6, f. 3; Desm. Ital. 1876, p. 28; Wille, Fersky. Alg. Nov. Semlj. 1879, p. 35; Wolle, Desm. U. S. 1884, p. 76, t. 14, f. 4? (not fig. 3); Cooke, Brit. Desm. 1887, p. 109, t. 41, f. 3; Boldt, Desm. Grönland, 1888, p. 29; De Toni, Syll. Alg. 1889, p. 992; West, Alg. N. Wales, 1890, p. 290; Anderss. Sverig. Chlor. 1890, p. 14; West, Alg. Engl. Lake Distr. 1892, p. 728; Börg. Fersky. Alg. Östgrönl. 1894, p. 13; Roy & Biss. Scott. Desm. 1894, p. 169; Nordst. Index Desm. 1896, p. 187; West & G. S. West, Alg. S. England, 1897, p. 490; G. S. West, Alga-fl. Cambr. 1899, p. 219; West & G. S. West, Alga-fl. Yorks. 1900, p. 83; Lütkem. Desm. Millstättersees, 1900, p. 10; Börg. Freshw. Alg. Færoës, 1901, p. 228; West & G. S. West, Alg. N. Ireland, 1902, p. 40; Larsen, Freshw. Alg. E. Greenland, 1904, p. 87; West & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 21; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 180.

C. Botrytis A. d. *ochthodes* Klebs, Desm. Ostpreuss. 1879, p. 39.

? ? *C. Botrytis* var. *squamosum* Schaarschm. Magyar. Desm. 1883, p. 263.

Ursinella ochthodes Kuntze, Revis. gen. plant. 1891, p. 925.

Cells rather large, from $1\frac{1}{3}$ to almost $1\frac{1}{2}$ times as long as broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells ovate-pyramidate from a flat base, basal angles obtuse or scarcely rounded, sides convex and upwardly converging to a rather narrow, truncate apex (sometimes slightly retuse); sides conspicuously crenate or only undulate, crenations 11–13 (commonly 12), small and rounded at the basal angles, but larger and flattened above. Side view of semicell obovate. Vertical view elliptic. Cell-wall densely covered with flattened warts of somewhat indefinite outline (irregularly circular), disposed in rather irregular radial and concentric series, and gradually becoming less distinct towards the centre of the semicell, which is also often punctulate. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore globose, furnished with a few short, very thick spines (about 11 visible around the margin); apices of spines obtuse or slightly emarginate.

Length 70–94 μ; breadth 51–67 μ; breadth of isthmus 17·5–27 μ; breadth of apex 19–25 μ; thickness 34–43 μ; diam. zygosp. without spines 60 μ, with spines 76 μ; length of spines 6–7·5 μ.

England.—Cumberland! Westmoreland! (*Bissett*). Lancashire! W. and N. Yorks (zygospores from Lund's Fell, N. Yorks)! Cheshire (*Roy*). Leicestershire (*Roy*). Worcestershire! Warwickshire! Essex! Cambridgeshire! Oxfordshire! Surrey! Hants (*Bennett*). Somerset! Devon! Cornwall! Channel Islands (Jersey)!

Wales.—General in Carnarvonshire (at over 3000 ft. on Snowdon)! Merioneth!

Scotland.—Ross, Inverness, Aberdeen!, Forfar!, Perth!, Stirling, Fife (*Roy & Bissett*). Sutherland! Outer Hebrides! Orkneys! Shetlands!

Ireland.—Achill Island, and near Westport, Mayo! Derryclare Lough, Galway! Slieve Donard, Down (at 2000 ft.)! Carrantuohill, Kerry! Cork!

Geogr. Distribution.—France. Germany. Austria and Galicia. Bosnia. Roumania. Italy. Norway. Sweden. Bornholm. Finland. Russian Lapland. N. Russia. Faeroes. Nova Zembla. Spitzbergen. Greenland. United States.

C. ochthodes should be carefully compared with *C. Botrytis* and *C. tetraophthalmum*, from both of which species it is very easily distinguished by the totally different nature of its surface-ornamentation. It is a widely distributed species in upland districts and is not uncommon on old heaths in the lowlands. The warts are broad, flattened elevations with a somewhat irregularly-circular outline, and they vary considerably in the extent of their development. In some individuals they are very prominent, causing the cell-margin to appear distinctly crenate, whereas in others they are much more flattened, the cell-margin only appearing undulate.

Var. **amœbum** West. (Pl. XCVIII, figs. 4–6.)

C. ochthodes var. *amœbum* West, Alg. Engl. Lake Distr. 1892, p. 728; West & G. S. West, Alga-fl. Yorks. 1900, p. 84; Freshw. Alg. Orkneys and Shetlands, 1905, p. 21.

C. ochthodes forma *granulosum* Lütkem. Desm. Attersees, 1893, p. 557, t. 8, f. 9.

C. ochthodes var. *amœbo-granulosum* Schmidle, Alg. Bern. Alp. 1894, p. 92, t. 6, f. 9.

C. speciosum Lund. var. *australianum* Nordst. forma Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 50, t. 1, f. 35 *a*; t. 2, f. 35 *b*. [=*C. ochthodes* var. *amœbum* according to Gutwinski, 1895.]

Semicells pyramidate-trapeziform, with broader apices than in the type, margins only faintly undulate; warts very broad and flat, scarcely elevated, and sinuous in outline; cell-wall between the warts sparsely punctate.

Length 87–90 μ; breadth 60–67 μ; breadth of apex 25–27 μ; breadth of isthmus 21 μ; thickness 40 μ.

England.—Foot of Brant Fell, Westmoreland! Hampsfell and Hawkshead, Lancashire! Mickle and Cronkley Fells, N. Yorks!

Scotland.—Sutherland! Skye in Inverness! Hoy, Orkneys! Near Scalloway and Bressay, Shetlands!

Ireland.—Lough Gartan, Donegal! Bog near Lough Neagh, Londonderry!

Geogr. Distribution.—Austria and Galicia. Switzerland. Lapland. Spitzbergen.

This variety is about the same in size as the type, but the semicells are more trapeziform, possessing broader apices. The outline is but faintly undulate (much less undulate than in the type), and the greatly depressed warts are very broad towards the centre of the semicells. They are of almost inappreciable elevation and sinuous in outline (hence the varietal name "*amœbum*").

We sometimes find this variety and the type abundantly in the same collection, in which case the differences stand out most clearly. They can always be distinguished by outward form alone, although the character of the cell-margin and the sinuous "warts" are the principal features of the variety.

Var. **subcirculare** Wille. (Pl. XCVIII, fig. 7.)

C. ochthodes var. *subcirculare* Wille, Norges Ferskv. Alg. 1870, p. 26, t. 1, f. 8; G. S. West, Alga-fl. Cambr. 1899, p. 219; West & G. S. West, 1900, p. 84; Wille, Algolog. Notiz. VII. 1901, p. 17.

Cells smaller than in the type, only a little longer than broad; semicells subsemicircular, margins uniformly undulate, and within the margins with 3

concentric series of flattened granules; vertical view oblong-elliptic, poles 6–7-undulate.

Length 48 μ; breadth 42 μ; breadth of isthmus 15 μ; thickness 23 μ.

England.—Baildon and Boston Spa, W. Yorks! Wimpole Park, Cambridgeshire!

Geogr. Distribution.—Norway.

229. **Cosmarium coronatum** Cooke & Wills.

(Pl. XCVIII, fig. 8.)

Cosmarium coronatum Cooke & Wills in Cooke, 'Notes on Brit. Desmids,' Grevillea, 1881, ix, p. 90; Wills in Midland Naturalist, 1881, iv, p. 74, t. 5, f. 2; Cooke, Brit. Desm. 1887, p. 108, t. 41, f. 7; De Toni, Syll. Alg. 1889, p. 1023; Nordst. Index Desm. 1896, p. 83.
Ursinella coronata Kuntze, Revis. gen. plant. 1891, p. 924.

Cells of medium size, a little broader than long, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells transversely subrect-angular-trapeziform, angles rounded, sides upwardly diverging, apex broad and slightly convex. Side view of semicell depressed-globose, with a subtruncate apex. Vertical view elliptic, ratio of axes about 1 : 1·8. Cell-wall coarsely and somewhat distantly granulate, granules rounded, arranged in three transverse series (about 8 in each series) and with 15 or 16 visible at the margin of the semicell.

Zygospore unknown.

Length 65–70 μ; breadth 75–80 μ; breadth of isthmus 20 μ; thickness 45 μ.

Wales.—Capel Curig, Carnarvonshire (*Cooke & Wills*).

We have never seen this species, nor, in fact, any *Cosmarium* with a granulation such as that described and figured by Messrs. Cooke and Wills for *C. coronatum*.

230. **Cosmarium conspersum** Ralfs.

(Pl. XCIX, figs. 1, 2.)

Cosmarium conspersum Ralfs, Brit. Desm. 1848, p. 101, t. 16, f. 4; Arch. in Pritch. Infus. 1861, p. 732; Rabenh. Flor. Europ. Alg. III, 1868, p. 159; Cooke, Brit. Desm. 1887, p. 101, t. 39, f. 1; De Toni, Syll. Alg. 1889, p. 998; Borge, Chlor. Norska Finmark. 1892, p. 9; West, Alg. W. Ireland, 1892, p. 152; Alg. Engl. Lake Distr. 1892, p. 726; Lütkem.

Desm. Attersees, 1893, p. 557; Roy & Biss. Scott. Desm. 1894, p. 44; Schmidle, Beitr. alp. Alg. 1895, p. 454; Nordst. Index Desm. 1896, p. 79; W. & G. S. West, Alg. S. England, 1897, p. 488; Schmidle, Lappmark Süsswasseralgen, 1898, p. 35; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88; ? Hirn, Desm. Finland, 1903, p. 8; Larsen, Freshw. Alg. E. Greenland, 1904, p. 84.

C. anomalum Delp. Desm. subalp. 1877, p. 29, t. 9, f. 10–15 [in part].

C. conspersum a. *Ralfsii* Racib. Nonn. Desm. Polon. 1885, p. 75.

Ursinella conspersa Kuntze, Revis. gen. plant. 1891, p. 924.

Cells large, about $1\frac{1}{3}$ times as long as broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells subrectangular, slightly wider at the apex than at the base, angles slightly rounded, sides almost straight, apex convex (in some specimens much more than in others); cell-wall uniformly granulate, about 30 granules showing round the margin of a semicell, granules disposed in about 9 horizontal series and 13–15 vertical series, commonly with slight irregularities. Side view of semicell almost circular. Vertical view elliptic, ratio of axes about 1 : 1·6. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 82–110 μ; breadth (max.) 65–77 μ; breadth of isthmus 20–27 μ; thickness 40–46 μ.

England.—Westmoreland (*Bissett*). Malham Tarn, W. Yorks. Mickle and Great Shunnor Fells, N. Yorks! Sutton Park, Warwickshire! (*Wills*). Sussex (*Ralfs*). Keston Common, Kent!

Wales.—Capel Curig (*Cooke & Wills*), Bettws-y-Coed (*Roy*), and near Bethesda!, Carnarvonshire. Llyn Coron, Anglesey! Dolgelly, Merionethshire (*Ralfs*).

Scotland.—Glen Tilt and Ben Lawers, Perth!

Ireland.—Clifden to Roundstone, and Creggan Lough, Galway! Adrigole, Cork! Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Austria. Galicia. Roumania. Italy. Norway. Sweden. Bornholm. Finland. Poland. N. Russia. Iceland. Nova Zembla. Greenland. United States. Brazil. Paraguay.

Typical *C. conspersum* is a very uncommon Desmid. We have seen no specimens exactly similar to the figure given by Ralfs, the apices being generally more convex and the con-

striction not quite so deep. The granules are disposed in fairly regular transverse and vertical series, and the cell-wall between the granules is quite smooth. The vertical view is elliptical with no flattening of the sides.

The var. *latum* (= *C. latum* Bréb.) and other forms with more rounded semicells are much more frequent than the somewhat angular Desmid described by Ralfs, although for the most part these forms have been recorded under the name "*C. conspersum.*"

Borge ('Chlor. Norska Finmark.' 1892, p. 9) has recorded a "forma *minor*" of this species from the extreme north of Norway with a length of only 52 μ and a breadth of 44 μ.

Var. **latum** (Bréb.) *nob.* (Pl. XCIX, figs. 5, 6.)

Cosmarium latum Bréb. Liste Desm. 1856, p. 128, t. 1, f. 10; Rabenh. Flor. Europ. Alg. III, 1868, p. 158; ? Cooke, Brit. Desm. 1887, p. 101, t. 41, f. 8; De Toni, Syll. Alg. 1889, p. 999; West, Alg. N. Yorks, 1889, p. 292; Roy & Biss. Scott. Desm. 1894, p. 105, t. 2, f. 10; Nordst. Index Desm. 1896, p. 156; W. & G. S. West, Alg. S. England, 1897, p. 488; Some Desm. U. S. 1898, p. 306; Alga-fl. Yorks. 1900, p. 88; Börg. Freshw. Alg. Færoës, 1901, p. 227; Borge, Süsswasseralgen Sud. Patagon. 1901, p. 21; W. & G. S. West, Alg. N. Ireland, 1902, p. 37; Borge, Beiträge Alg. Schweden, 1906, p. 30; W. & G. S. West, Freshw. Alg. Burma, 1907, p. 206.

C. anomalum Delp. Desm. subalp. 1877, p. 29, t. 9, f. 10–12, and 15 [figures poor and inaccurate].

Ursinella lata Kuntze, Revis. gen. plant. 1891, p. 925.

Cells proportionately wider; semicells generally with a conspicuous upward dilation, so that the apical part is distinctly wider than the basal part, apex usually (but not always) more convex; granules about equal in size and number to those of typical *C. conspersum*, arranged in vertical and indistinct oblique series.

Length 88–107 μ; breadth 76–88 μ; breadth of isthmus 27·5–34 μ; thickness 40–50 μ.

England.—Near Bowness, Westmoreland! (*Bissett*). Mickle and Great Shunnor Fells, Pilmoor, and Carlton Bank, N. Yorks! Delamere, Cheshire (*Roy*). Brent Reservoir, Middlesex!

Wales.—Capel Curig!, Llyn Ogwen!, and Glyder Fawr (*Roy*), Carnarvonshire.

Scotland.—Sutherland!, Ross, Inverness, Aberdeen, Kincardine, Forfar, Perth!, Stirling (*Roy & Bissett*). Lewis and Harris, Outer Hebrides!

Ireland.—Errigal, Donegal! Slieve Commedagh, Down! Frequent in Mayo and Galway!

Geogr. Distribution.—France. Germany. Italy. Roumania. Norway. Sweden. Denmark. Faeroes. Greenland. Central China (a form). Celebes. United States. Patagonia.

Brébisson's original figure of *Cosmarium latum* does justice neither to the angularity of this Desmid nor to the disposition of its granules. The figure given by Messrs. Roy and Bissett in 1894 was the first one to portray its salient features. We find it impossible, however, to separate *C. latum* as a species from *C. conspersum*. The differences are too slight, and many intermediate conditions exist. The var. *latum* is much more generally distributed than typical *C. conspersum*, and differs chiefly in its slightly greater breadth and more convex apices. The granulation of the two forms is very similar, and in both cases the cell-wall between the granules is smooth. The ratio of the breadth to the length in *C. conspersum* is 1 : 1·35, whereas in the var. *latum* the average ratio is 1 : 1·18.

Note:—Cosmarium latum Bréb. var. minor Roy & Biss. (Scott. Desm. 1894, p. 105, t. 2, f. 11 [= *C. similatum* Roy & Biss. MS.]; Gutw. Wykaz. Glonow Wadow.-Makow. 1897, p. 148; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88; Wittr., Nordst. et Lagerh. Alg. Exsic. 1903, no. 1481; fasc. 35, p. 13). This Desmid was obtained by Messrs. Roy & Bissett from above Loch Etchachan on Ben Macdhui in Aberdeenshire, and from Canlochan in Forfar, and we have obtained it from Boston Spa and Ogden Clough in West Yorkshire. It was described as "very like the type [*C. latum*] in form, but smaller and more closely granulated. Length 60–67 μ; breadth 48–55 μ; isthmus 20–22 μ." We give a copy of their figure on Pl. XCIX, fig. 7, but we consider that this Desmid is not correctly placed with the forms of *Cosmarium conspersum* Ralfs. The semicells are too rounded, and the granulation is both finer and denser. Its dimensions and its granulation are those of *Cosmarium Logiense* Bissett [*vide* Vol. III, Pl. LXXX, figs. 1 and 2], with which species it should more rightly be placed. It might be called C. Logiense Biss. forma expansa nob.

Var. **rotundatum** Wittr. (Pl. XCIX, fig. 3.)

C. conspersum Ralfs var. *rotundatum* Wittr. Skandinav. Desm. 1869, p. 13, f. 4; Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 35; De Toni, Syll. Alg.

1889, p. 998; Borge, Chlor. Norska Finmark. 1892, p. 9; Lütkem. Desm. Attersees, 1893, p. 558; Börg. Ferskv. alg. Östgrönl. 1894, p. 13; Gutw. Flor. Glon. Okolic Tarnapola, 1894, p. 95; Roy & Biss. Scott. Desm. 1894, p. 44; Lütkem. Desm. Millstättersees, 1900, p. 8; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88; Borge, Beiträge Alg. Schweden, 1906, p. 30.

C. conspersum b. *rotundatum* forma *scandinavica* Racib. Nonn. Desm. Polon. 1885, p. 75; Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 53.

Relative length and breadth similar to that of var. *latum*; lateral margins of semicells subparallel; granules typical, disposed in transverse and vertical series.

Length 86–110 μ; breadth 66–80 μ; breadth of isthmus 25–33 μ; thickness 37–55 μ.

England.—Skipwith Common, E. Yorks!

Wales.—Glyder Fawr, Carnarvonshire (*Roy*).

Scotland.—Ross, Inverness, Aberdeen, Kincardine, Stirling (*Roy & Bissett*).

Geogr. Distribution.—Germany. Austria and Galicia. Roumania. Norway. Sweden. Nova Zembla. India.

This variety as we know it is in no way inferior in size to typical *C. conspersum*, but other observers have recorded much smaller forms. Raciborski records both a "forma *intermedia*" (length 70–72 μ; breadth 55–61 μ) and a "forma *minor*" (length 54–55 μ; breadth 43 μ) from Poland; and Boldt describes and figures a rather small form from Greenland in which the semicells possess upwardly diverging sides (length 72–82 μ; breadth 52·2–64·8 μ). It may be, however, that these forms would be better referred to the var. *latum*.

Var. **subrotundatum** West. (Pl. XCIX, fig. 4.)

C. conspersum Ralfs var. *subrotundatum* West, Alg. W. Ireland, 1892, p. 152, t. 21, f. 7.

Superior angles of semicells greatly rounded; granules rather more numerous, disposed in about 12 horizontal and 21 vertical series.

Length 84 μ; breadth 82 μ; breadth of isthmus 30 μ; thickness 42 μ.

Ireland.—Cromagloun, Kerry!

It might be mentioned here that the most dilated and rounded of all the *Cosmaria* of this type is a North American species with greatly inflated semicells, which has been described as *Cosmarium Johnsonii* W. & G. S. West ('Some Desm. U. S.' 1898, p. 306, t. 17, f. 4).

231. **Cosmarium margaritatum** (Lund.) Roy & Biss. (Pl. XCIX, figs. 8, 10.)

Cosmarium latum Bréb. var. *margaritatum* Lund. Desm. Suec. 1871, p. 26; Nordst. Norges Desm. 1873, p. 12; Boldt, Desmid. Grönland, 1888, p. 26; De Toni, Syll. Alg. 1889, p. 999.

C. margaritatum (Lund.) Roy & Biss. Jap. Desm. 1886, p. 194; West, Freshw. Alg. Maine II, 1891, t. 315, f. 16; Roy & Biss. Scott. Desm. 1894; p. 167, t. 2, f. 12; Johnson, Rare Desm. U. S. II, 1895, p. 292, t. 240, f. 32; Nordst. Index Desm. 1896, p. 165; W. & G. S. West, Desm. Singapore, 1897, p. 165; Alg. S. England, 1897, p. 488; Schmidle, Lappmark Süsswasseralgen, 1898, p. 35; G. S. West, Alga-fl. Cambr. 1899, p. 217; W. & G. S. West, Alg. N. Ireland, 1902, p. 37; Freshw. Alg. Ceylon, 1902, p. 169; Freshw. Alg. Orkneys and Shetlands, 1905, p. 21; G. S. West, Alg. Third Tanganyika Expedit. 1907, p. 122.

Cells fairly large, about $1\frac{1}{5}$ times as long as broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells subrectangular (sometimes ellipsoid-subrectangular), apex very slightly convex, sides slightly convex, never upwardly divergent, basal angles rounded, superior angles broadly rounded; cell-wall uniformly granulate, from 28 to 32 granules showing round the margin of a semicell; granules solid, disposed in oblique decussating series, about 12 series in each direction, and also in indistinct vertical series, cell-wall between the granules punctate, the punctulations arranged in hexagons around each granule. Side view of semicell subcircular. Vertical view oblong-elliptic with convex sides. Chloroplasts axile, two pyrenoids in each semicell.

Zygospore unknown.

Length 66–105 μ; breadth 56–82 μ; breadth of isthmus 19–31 μ; thickness 40–48 μ.

England.—Austwick Moss, W. Yorks! Chippenham Fen, Cambridge! Frensham Great Pond and Thursley Common (very abundant), Surrey! New Forest, Hants!

Wales.—Llyn-y-cwm-ffynon and Capel Curig, Carnarvonshire! Plankton of several of Welsh Lakes!

Scotland.—Pool near View Rock, Strathpeffer, Ross; Slewdrum, Aboyne, Cambus O'May, Dalbagie, Glen Clunie, and Castleton, Aberdeen (*Roy & Bissett*). Plankton of Loch Doon, Ayr! Rhiconich, Sutherland!

Harris and Lewis, Outer Hebrides! Orkneys! Shetlands!

Ireland.—Lough Anna, Donegal! Dublin and Wicklow (*Archer*). Lough Derryclare, and near Roundstone, Galway! Foxford, Mayo!

Geogr. Distribution.—France (f. *minor*). Germany. Galicia in Austria (f. *minor*). Norway. Sweden. Greenland. Ceylon. Singapore. W. and Central Africa. United States. W. Indies. Brazil (f. *minor*).

It is a doubtful question whether *C. margaritatum* should be separated from *C. conspersum* as a species, or whether it should be placed as a variety in close association with the var. *latum*. Its complete separation is, however, a convenience, as it is the only British *Cosmarium* of this type with well-marked punctulations between the granules. The granulation is constant in character, but the granules exhibit considerable variation in size in different individuals. The basal portion of the semicell is generally distinctly wider than the apical part, owing to the greater rounding of the apical angles. The slight differences in the outward form of the semicells, and the presence of regularly arranged punctulations between the granules, are the only characters which separate *C. margaritatum* from *C. conspersum* var. *latum*.

The smaller forms of this species are known as :—

Forma minor (Boldt) W. & G. S. West, Welw. Afric. Freshw. Alg. 1897, p. 121 ; *C. latum* var. *margaritatum* forma *minor* Boldt, Desmid. Grönland, 1888, p. 26. Length 44–62 μ; breadth 38–48 μ; breadth of isthmus 12·5–13·5 μ; thickness 25–30 μ. (Pl. XCIX, fig. 9.)

The largest forms we have observed occurred in abundance at Chippenham Fen, Cambridgeshire, and reached a length of 105 μ. This is slightly larger than the Desmid described as "*C. margaritatum* var. *major*" by Schmidle (' Alg. Carolin.' 1901, p. 347, t. 12, f. 5), but that seems scarcely to belong to *C. margaritatum* on account of its different proportions and its smooth apices.

Forma **subrotundata** *nob.* (Pl. C, fig. 1.)

Semicells relatively wider and more rounded, almost reniform in outline; granules hollow (excavated from the interior).

Length 92 μ; breadth 80 μ; breadth of isthmus 31 μ.

Wales.—In the Plankton of Llynau Dywaunedd, Carnarvonshire!

Scotland.—Rhiconich, Sutherland!

In this form the semicells are much more rounded than usual, and the hollow granules are similar to those of *C. sublatum* Nordst. and *C. Pardalis* Cohn.

232. **Cosmarium Quadrum** Lund.
(Pl. C, figs. 3–6.)

Cosmarium Quadrum Lund. Desm. Suec. 1871, p. 25, t. 2, f. 11; Boldt, Siber. Chlorophy. 1885, p. 107; Cooke, Brit. Desm. 1887, p. 102, t. 42, f. 1; Boldt, Desmid. Grönland, 1888, p. 26; De Toni, Syll. Alg. 1889, p. 985; Anderss. Sverig. Chlor. 1890, p. 14; West, Alg. Engl. Lake Distr. 1892, p. 726; Roy & Biss. Scott. Desm. 1894, p. 173; Nordst. Index Desm. 1896, p. 218; Schmidle, Lappmark Süsswasseralgen, 1898, p. 34; ? Ost-Afrika Desmid. 1898, p. 26; Borge, Trop. u. subtrop. Süssw.-Chlor. 1899, p. 20; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88; Freshw. Alg. Ceylon, 1902, p. 170 [forma]; Borge, Beiträge Alg. Schweden, 1906, p. 30; G. S. West, Alg. Third Tanganyika Expedit. 1907, p. 122 [forma].

C. conspersum Ralfs *c. Quadrum* Racib. Nonn. Desm. Polon. 1885, p. 75.

Ursinella Quadrum Kuntze, Revis. gen. plant. 1891, p. 925.

Cells of medium size, in general outline quadrate, about as long as broad or slightly longer, deeply constricted, sinus narrowly linear, with a slightly dilated extremity; semicells subrectangular, basal angles rounded, superior angles broadly rounded, sides slightly convex (sometimes almost straight), apex generally very slightly retuse, sometimes straight. Side view of semicell subcircular. Vertical view oblong-elliptic, with straight parallel sides. Cell-wall densely granulate; granules solid, arranged in decussating oblique series and in somewhat less distinct vertical series, from 34 to 37 showing at the margin of a semicell, and slightly reduced in size in the middle of the apex. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 60–83 μ; breadth 54–74 μ; breadth of isthmus 18–29 μ; thickness 27–40 μ.

England.—Brant Fell and near Bowness, Westmoreland! Cullingworth, W. Yorks!

Wales.—Capel Curig, Carnarvonshire!

Scotland.—Loch Inver, Sutherland; Pittellachie

and Tomachar in Cromar, Aberdeen; near source of the Barvie, Kincardine (*Roy & Bissett*). Ben Lawers, Perth! Argyll!

Ireland.—Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Galicia in Austria. Norway. Sweden. Bornholm. Finland. Poland. N. Russia. India. Ceylon (var.). Sumatra. Samoa (var.). Central Africa. United States.

C. Quadrum is the rarest of the *C. conspersum*-group in the British Islands, although one of the most frequent tropical species. It is distinguished from all forms of *C. conspersum* and *C. margaritatum* by the rectangular semicells with a broad flattened apex which is slightly retuse in the middle. The vertical view is also oblong with parallel sides, and the granules are invariably reduced in size in the median portion of the apex of each semicell. The cell-wall between the granules is quite smooth.

The smaller forms of this species are known as:—

Var. minus Nordst. Norges Desm. 1873, p. 11; De Toni, Syll. Alg. 1889, p. 985; Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 101; Börg. Ferskv. Alg. Östrgrönl. 1894, p. 14; etc. Length 38–50 μ; breadth 38–48 μ; thickness 18–23 μ.

C. Pseudobroomei Wolle var. *madagascariense* W. & G. S. West, Alg. Madag. 1895, p. 63, t. 7, f. 34 is very near to *C. Quadrum* var. *minus*. It differs from the latter, however, in its convex apices and in the reduction of the granules near the centre of the semicells. It might best be regarded as a form of *C. Quadrum* under the name "C. Quadrum var. madagascariense nob."

Two other Desmids require mentioning in reference to *C. Quadrum*. The first one is *C. sublatum* Nordst. ('Freshw. Alg. N. Zeal. & Austral.' 1888, p. 45, t. 5, f. 1–4). We give a figure of a specimen from Australia (Victoria) for comparison with the figures of *C. Quadrum*. It differs only in two points, in the hollow granules and in the intergranular punctulations. These are scarcely specific differences, as even a form of *C. margaritatum* is known with hollow granules. It would be better placed as C. Quadrum var. sublatum (Pl. C, fig. 2).

The second one is *C. Pardalis* Cohn, which is more especially a tropical species. It is more angular than *C. Quadrum*, with larger granules and intergranular punctulations. It is

interesting as being the only species of the *C. conspersum*-group of which the zygospore is known. This spore is smooth and globular (*vide* West, 'Freshw. Alg. Maine' II, 1891, p. 355, t. 315, f. 10).

233. **Cosmarium Pseudobroomei** Wolle.

(Pl. C, figs. 7, 8; Pl. CIII, fig. 7.)

Cosmarium Broomei Ralfs, Brit. Desm. 1848 [in part], t. 33, f. 7.
C. Pseudobroomei Wolle in Bull. Torr. Bot. Club, 1884, p. 16, t. 44, f. 36, 37; Desm. U. S. 1884, p. 86, t. 51, f. 36, 37; Turner, Freshw. Alg. E. India, 1893, p. 66, t. 9, f. 41; Nordst. Index Desm. 1896, p. 208; Borge, Austral. Süsswasserchlor. 1896, p. 20, t. 3, f. 34; Borge, Trop. u. subtrop. Süssw.-Chlor 1899, p. 20, t. 1, f. 22; Lütkem. Desm. Central China, 1900, p. 119; W. & G. S. West, Freshw. Alg. Ceylon, 1902, p. 170; Gutw. Alg. Ins. Java, 1902, p. 601; G. S. West, Alg. Third Tanganyika Expedit. 1907, p. 123.

Cells small, about as long as broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells oblong-rectangular with the angles slightly rounded, sides very slightly convex, apex straight or very slightly convex. Side view of semicell subcircular. Vertical view oblong, with subparallel sides and broadly rounded extremities. Cell-wall densely granulate; granules small and solid, arranged in decussating oblique series and in somewhat less distinct vertical series (as in *C. Quadrum*), from 23 to 32 showing at the margin of a semicell. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore subglobose and smooth.

Length 33–38 μ; breadth 29–36 μ; breadth of isthmus 8·5–12 μ; thickness 16–17·5 μ.

Wales.—Capel Curig and Llyn-y-cwm-ffynon, Carnarvonshire!

Geogr. Distribution.—Galicia in Austria. Central China. India. Ceylon. Java. Madagascar (var.). E. Africa (var.). Central Africa. United States. Brazil.

There is little doubt that the zygospore figured by Ralfs on his supplementary plate 33 under the name of "*C. Broomei*" is that of *C. Pseudobroomei*. The latter is distinguished from *C. Broomei* by the entire absence of a median inflation in the vertical view, and by its somewhat coarser granulation.

C. Pseudobroomei approaches very closely the smaller forms

of *C. Quadrum* var. *minus*. Borge records Australian specimens up to a length and breadth of 45·5 μ.

Another closely allied species is *C. creperum* W. & G. S. West ('Alg. Madag.' 1895, p. 63, t. 7, f. 11), which differs in the open sinus, the more rounded sides of the semicells, and the more distantly arranged granules.

The granulation of *C. Pseudobroomei* appears to be variable in density, some specimens exhibiting many more granules per semicell than others.

Var. **convexum** W. & G. S. West. (Pl. C, fig. 9.)

C. Pseudobroomei var. *convexum* W. & G. S. West, Freshw. Algæ Orkneys and Shetlands, 1905, p. 21, t. 1, f. 22.

Lateral margins of semicells convex and with the angles more rounded; granules as in the type but disposed most evidently in vertical series.

Length 46 μ; breadth 37·5 μ; breadth of isthmus 12·5 μ; thickness 24 μ.

Scotland.—Near Lerwick, Shetlands!

This variety is slightly larger than any other known form of the species, and is proportionately less wide.

234. **Cosmarium Subbroomei** Schmidle. (Pl. C, fig. 10.)

Cosmarium Subbroomei Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 104, t. 5, f. 22–24.

Cells small, about as long as broad, very deeply constricted, sinus narrowly linear with a very slightly dilated apex; semicells oblong-rectangular with slightly rounded angles, sides and apex very slightly convex. Cell-wall finely granulate; granules about the size of those of *C. punctulatum*, disposed in 10–12 subvertical series, 25–27 showing at the margin of a semicell, with a few indistinctly arranged granules just above the isthmus in the centre of the semicell. Side view of semicell subcircular. Vertical view rather narrowly elliptical, with three prominent papilla-like granules at the middle on each side. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 40 μ; breadth 36 μ.

Geogr. Distribution.—Germany.

The illustration on Pl. C (fig. 10) is copied from one of Schmidle's original figures. We have seen nothing *exactly* like it from the British Islands, although we have met with a *Cosmarium* from Surrey which must be regarded as a form of it.

Forma. (Pl. C, fig. 11).

Semicells slightly trapeziform, granules somewhat more numerous; in the vertical view with a very slight granulated protuberance at the middle on each side. Length 42 μ; breadth 38 μ; breadth of isthmus 12 μ; thickness 23 μ.

England.—In a mill-pond E. of Chapel Wood in S.E. Surrey!

235. **Cosmarium Broomei** Thwaites.

(Pl. C, fig. 12.)

Cosmarium Broomei Thwaites in Ralfs' Brit. Desm. 1848, p. 103, t. 16, f. 6; Arch. in Pritch. Infus. 1861, p. 734, t. 1, f. 7; Rabenh. Flor. Europ. Alg. III, 1868, p. 171; Lund. Desm. Suec. 1871, p. 29; Nordst. Desm. Ital. 1876, p. 41; Kirchn. Alg. Schles. 1878, p. 154; ? Wolle, Desm. U. S. 1884, p. 86, t. 17, f. 6, 7; Cooke, Brit. Desm. 1887, p. 109, t. 40, f. 1; Hansg. Prodr. Algenfl. Böhm. 1888, p. 251; De Toni, Syll. Alg. 1889, p. 1026; West, Alg. N. Yorks. 1889, p. 292; Alg. N. Wales, 1890, p. 290; Alg. W. Ireland, 1892, p. 156; Alg. Engl. Lake Distr. 1892, p. 728; Roy & Biss. Scott. Desm. 1894, p. 44; Nordst. Index Desm. 1896, p. 70; W. & G. S. West, Alg. S. England, 1897, p. 490; Alga-fl. Yorks. 1900, p. 88.

Ursinella Broomei Kuntze, Revis. gen. plant. 1891, p. 924.

Cells rather small, almost quadrate, about as long as broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells oblong-rectangular or rectangular-trapeziform, with the angles slightly rounded, sides convex and sometimes slightly convergent upwards, apex straight or faintly retuse. Side view of semicell subcircular-depressed. Vertical view narrowly elliptic, with a conspicuous rounded inflation at the middle on each side. Cell-wall densely and finely granulate, granules quite small and disposed in close vertical series, about 30–34 showing at the margin of a semicell. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 42–52 μ; breadth 32–45 μ; breadth of isthmus 12–16 μ; thickness 21–30 μ.

England.—Crummock Water, Cumberland! Loughrigg, Westmoreland! Risley Bog, Lancashire! Cullingworth, Wigton Moor, Baildon, Adel Bog, and Moughton Fell, W. Yorks! Pilmoor, Mickle and Great Shunnor Fells, N. Yorks! Riccall Common, E. Yorks! Gloucester (*Ralfs*). Near Chapel Wood, Surrey! Sussex! Hants (*Bennett*). Cornwall (*Marquand*).

Wales.—Bethesda!, Capel Curig!, Snowdon!, and Glyder Fawr (*Roy*), Carnarvonshire. Dolgelly, Merioneth!

Scotland.—Near Brin, Inverness; near Alford, Aberdeen; Strachan, Kincardine (*Roy & Bissett*).

Ireland.—Near Westport, Mayo! Near Recess, Galway!

Geogr. Distribution.—France. Germany. Galicia in Austria. Italy. Norway. Sweden. Denmark. S. Russia. United States. Brazil.

C. Broomei differs from all allied species in the possession of a large protuberance in the middle of each semicell. The granulation is also characteristic, being very fine, and comparable to that of *C. biretum*. It is a rare Desmid and we have only met with it as solitary examples.

The zygospore of this species is as yet unknown, as that figured by Ralfs ('Brit. Desm.' 1848, t. 33, f. 7) is most probably that of *C. Pseudobroomei*. It is not unlikely, however, that the zygospore of *C. Broomei* will be found to be smooth.

The *Cosmarium* figured by Wolle ('Desm. U. S.' 1884, t. 17, f. 8, 9) as a "smaller variety and zygospore" of *C. Broomei* is now known as another species—*C. spinosporum* Lagerh.

236. **Cosmarium biretum** Bréb.

(Pl. CI, figs. 1–8.)

Cosmarium biretum Bréb. in Ralfs' Brit. Desm. 1848, p. 102, t. 16, f. 5; Arch. in Pritch. Infus. 1861, p. 733; Rabenh. Flor. Europ. Algar. III, 1868, p. 171; Lund. Desm. Suec. 1871, p. 30; Nordst. Desm. Arctoæ, 1875, p. 26; Desm. Ital. 1876, p. 40; Kirchn. Alg. Schles. 1878, p. 154; Wolle, Desm. U. S. 1884, p. 86, t. 17, f. 1, 2 [figures bad]; Cooke, Brit. Desm. 1887, p. 108, t. 39, f. 5 [figures bad]; Hansg. Prodr. Algenfl. Böhm. 1888, p. 202, 251; Hoff in Nordst. Bornh. Desm. 1888, p. 195;

Nordst. Freshw. Alg. N. Zeal. 1888, p. 78; De Toni, Syll. Alg. 1889, p. 1018; Racib. Desm. Nowe, 1889, p. 92; West, Alg. N. Wales, 1890, p. 289; Heimerl, Desm. alp. 1891, p. 595; Roy & Biss. Scott. Desm. 1894, p. 43; Nordst. Index Desmid. 1896, p. 62; W. & G. S. West, Alg. S. England, 1897, p. 490; G. S. West, Variation Desm. 1899, p. 389, t. 10, f. 22–28; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88; Freshw. Alg. Ceylon, 1902, p. 169; Larsen, Freshw. Alg. E. Greenland, 1904, p. 83.

C. quadrangulatum Hantzsch in Rabenh. Alg. Sachs. 1860, No. 969; Rabenh. Flor. Europ. Alg. III, 1868, p. 170; De Toni, Syll. Alg. 1889, p. 1052.

? *C. anomalum* Delp. Desm. subalp. 1877, p. 29, t. 9, f. 14 [not f. 10–12, 15].

C. biretum var. *intermedium* Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 35, t. 12, f. 15.

C. biretum forma *grœnlandica* Boldt, Desmid. Grönland, 1888, p. 25, t. 2, f. 26.

C. biretum forma *subconspersa* Boldt, l. c. p. 25; Nordst. in Wittr. & Nordst. Alg. Exsic. 1896, no. 1266; 1903, fasc. 35, p. 13.

Ursinella bireta Kuntze, Revis. gen. plant. 1891, p. 924.

U. quadrangulata Kuntze, l. c. p. 925.

Cells rather under medium size, about as long as broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells somewhat variable in outline, commonly subrectangular-trapeziform, with the sides straight or slightly convex and upwardly diverging, basal angles slightly rounded, apical angles rounded (sometimes obliquely truncate or even slightly produced), apex usually convex (sometimes truncate in the middle). Side view of semicell subcircular or ovate. Vertical view elliptic, with a protuberance of variable magnitude (sometimes scarcely evident, at other times large) at the middle on each side. Cell-wall densely granulate; granules small, closely disposed in vertical series, or more frequently more or less irregularly arranged, from 40 to 54 showing at the margin of a semicell. Chloroplasts axile, with two prominent pyrenoids in each semicell.

Zygospore globose and smooth.

Length 54–74 μ; breadth 50–66 μ; breadth of isthmus 19–24 μ; thickness 35–42 μ.

A smaller form, which gradually merges into the above, is known as:—

Var. MINUS Hansg. Prodr. Algenfl. Böhm. 1888, p. 251; *C. biretum* forma *minor* Teodoresco, Matér. flor. alg. Rouman. 1907, p. 181.

Length 38–52 μ; breadth 35–52 μ; breadth of isthmus 13–19 μ; thickness 23 μ; diam. zygosp. 39–45 μ.

As it is impossible to draw an arbitrary line between the larger and smaller forms, they have not been discriminated in the following localities:—

England.—Cullingworth and Roundhay Park, W. Yorks! The Washes, Sutton, Cambridgeshire! Sutton Park, Warwickshire (*Wills*)! Middlesex (pure gathering from Brent Reservoir)! Surrey! Sussex (*Ralfs*). Wilts! Near St. Just, Cornwall (abundant)!

Wales.—Dolgelly, Merioneth!

Scotland.—Bridge of Don, Aberdeen; Garrol, Kincardine (*Roy & Bissett*).

Ireland.—Lower Lake of Killarney, Kerry! Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Galicia in Austria. Hungary. Italy. Roumania. Sweden. Bornholm. S. Russia. Nova Zembla. Spitzbergen. Greenland. Ceylon. New Zealand. United States.

C. biretum is by no means frequent, being found principally in the marshes and ditches of low-lying districts. It often occurs in great abundance among various species of *Potamogeton*, and may sometimes be obtained almost pure in the large drains of the east of England. When occurring in great quantity *C. biretum* generally exhibits many variations in form. The divergence of the lateral margins varies very much (consult figs. 2, 6, and 7 on Pl. CI), with the result that the semicells of some forms possess a much broader apex than those of others. The conformation of the apex is also markedly different in different individuals. In some it is straight or but slightly convex, and may even be retuse in the middle, whereas in others it is strikingly elevated, being very convex and often truncate in the median part (Pl. CI, figs. 4 and 7). Such differences may, however, be found in the semicells of the same individual.

The protuberance on each side of the vertical view is also a character which varies greatly. Sometimes it is very large, and all specimens show some signs of it, although in certain individuals it is scarcely appreciable.

The granulation of *C. biretum* is one of its most characteristic features.

The three described forms—var. *intermedium* Wille, forma *grænlandica* Boldt, and forma *subconspersa* Boldt—do not

possess any characters sufficiently definite to recognize them as distinct types. There is, however, a type of this species (var. *trigibberum*) which possesses characters by which it can always be identified, and which must, therefore, be regarded as a distinct variety.

Brébisson described a "forma TRIQUETRA" of this species. (Consult Bréb. 'Liste Desm.' 1856, p. 130, t. 1, f. 9; Rabenh. 'Flor. Eur. Alg.' III, 1868, p. 171; Cooke, 'Brit. Desm.' 1887, p. 109; etc.) The cells in vertical view are triangular with rounded angles, and there is a small inflation in the middle of each concave side. Breadth 56–59 μ. (Pl. CI, fig. 9.) This form has only been observed in France.

Var. **trigibberum** Nordst. (Pl. CI, figs. 10–15.)

C. biretum Bréb. subsp. *trigibberum* Nordst. Desm. Arctoæ, 1875, p. 26, t. 7, f. 19 [inclus. *C. biretum* forma *supernumeraria* Nordst. l. c. t. 7, f. 18]; Joshua in Journ. Bot. xxi, 1883, p. 291; De Toni, Syll. Alg. 1889, p. 1018; G. S. West, Variation Desm. 1899, p. 390, t. 10, f. 29–34; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88.

Cells usually larger than in the type; semicells of somewhat variable form, often more rounded; vertical view showing three small protuberances along each side.

Length 43–100 μ; breadth 38–82 μ; breadth of isthmus 12–33 μ; thickness 32–48 μ.

ENGLAND.—Roundhay Park, W. Yorks! The Washes, Sutton, Cambridgeshire! Sutton Park, Warwickshire! Near Cirencester, Gloucestershire (*Joshua*).

SCOTLAND.—Keithick, near Coupar-Angus, Perth (*Roy & Bissett*).

Geogr. Distribution.—Spitzbergen.

The distinguishing feature of this variety is the possession of three protuberances on each side in the vertical view, a central one and one close to each end. Considerable range of variation is shown in the outline, but we find the cells of var. *trigibberum* to be more rounded in general contour than those of typical *C. biretum*, and rarely to possess semicells with divergent lateral margins. The three protuberances on each side of the vertical view may be slight and more or less of equal size (Pl. CI, figs. 10 *b* and 13 *b*), or the central one may be much larger than the other two, the latter varying in their relative proximity to the ends (Pl. CI, figs. 11 *b* and 12 *b*).

The granulation is precisely like that of the type.

237. **Cosmarium amœnum** Bréb.

(Pl. CII, figs. 1–4; Pl. CIII, fig. 9.)

Cosmarium amœnum Bréb. in Ralfs' Brit. Desm. 1848, p. 102, t. 17, f. 3; Arch. in Pritch. Infus. 1861, p. 733; Rabenh. Flor. Europ. Alg. III, 1868, p. 159; Lund. Desm. Suec. 1871, p. 46; Kirchn. Alg. Schles. 1878, p. 152; Wolle, Desm. U. S. 1884, p. 78, t. 14, f. 5, 6 [figures very poor]; Cooke, Brit. Desm. 1887, p. 110, t. 40, f. 2 [figures poor]; Boldt, Desmid. Grönland, 1888, p. 29; De Toni, Syll. Alg. 1889, p. 988; Börg. Desm. Brasil. 1890, p. 37; Anderss. Sverig. Chlor. 1890, p. 14; West, Alg. N. Wales, 1890, p. 290; Alg. W. Ireland, 1892, p. 156; Alg. Engl. Lake Distr. 1892; p. 728; Lütkem. Desm. Attersees, 1893, p. 558; Roy & Biss. Scott. Desm. 1894, p. 41; Nordst. Index Desm. 1896, p. 43; W. & G. S. West, Alg. S. England, 1897, p. 488; Schmidle, Lappmark Süsswasseralgen, 1898, p. 35; W. & G. S. West, Alga-fl. Yorks. 1900, p. 88; Lütkem. Desm. Millstättersees, 1900, p. 7; W. & G. S. West, Alg. N. Ireland, 1902, p. 38; Borge, Beiträge Alg. Schweden, 1906, p. 29.
Ursinella amœna Kuntze, Revis. gen. plant. 1891, p. 924.

Cells somewhat small, almost twice as long as broad, moderately constricted, sinus rather variable, often slightly open and acute-angled (more rarely sublinear); semicells rounded-quadrate with sides and apex very slightly convex, sometimes semi-elliptic; cell-wall granulate, granules in more or less distinct vertical series (from 6 to 9 of these series visible across the face of a semicell), about 20–25 visible round the margin of a semicell, granules at the base of the semicell sometimes more or less regularly disposed in vertical pairs. Side view of semicell ovate-oblong or subelliptic-oblong. Vertical view broadly elliptic, ratio of axes 1 : 1·2. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 42·5–55 μ; breadth 23–30 μ; breadth of isthmus 11–17 μ; thickness 20–24 μ.

England.—Angle Tarn, Cumberland! Westmoreland! (*Ralfs*). Cocket Moss, W. Yorks! Strensall Common, N. Yorks! (*W. B. Turner*). Skipwith Common, E. Yorks! (*Rev. W. Fowler*). Surrey! Wilts! Cornwall! (*Marquand*).

Wales.—Capel Curig, Llyn-y-cwm-ffynon, bog between Glyder Fach and the river Llugwy, and Glyder Fawr, Carnarvonshire! Dolgelly, Merioneth!

Scotland.—Sutherland!, Inverness!, Aberdeen, Kincardine, Forfar, Perth!, Argyll (*Roy & Bissett*). Outer Hebrides! Shetlands!

Ireland.—Donegal! Mayo! Galway! Kerry! Dublin and Wicklow (*Archer*). Lough Neagh, Antrim.

Geogr. Distribution.—France. Germany. Austria and Galicia. Italy. Norway. Sweden. Denmark. Bornholm. S. Russia. Greenland. Ceylon. United States. Brazil.

Although widely distributed in the older bogs, *C. amœnum* is a very uncommon Desmid. Apart from the variation exhibited by the sinus, the cell has a very characteristic shape.

The granulation is not altogether uniform, and the vertical series are often very indistinct. Near the base of the semicell the granules are often associated in pairs, usually in a more or less irregular manner, but sometimes with sufficient regularity to give the appearance of a basal ring of paired granules. This feature may be present to a greater or less extent on one or both semicells, but owing to its great variability is of little importance.

C. amœnum var. *annulatum* Eichl. & Gutw. ('Nonn. spec. alg. nov.' 1894, p. 163, t. 4, f. 5), by reason of its general proportions, the form of its sinus, and the fewness of its granules, should be relegated to *C. pseudmœnum* var. *basilare* Nordst., notwithstanding the fact that two pyrenoids are present in each semicell. In very closely allied forms too much importance should not be placed upon the presence of solitary or binate pyrenoids in axile chloroplasts. [Consult *Cosmarium subcostatum*, *C. subcostatum* forma *minor*, and *C. subcostatum* var. *Beckii* in Vol. III, pp. 236–239.]

C. amœnum var. *Lundellii* Roy & Biss. ('Scott. Desm.' 1894, p. 42; *C. amœnum* forma major Lund. 'Desm. Suec.' 1871, p. 46), which Messrs. Roy and Bissett record from "Ross, Inverness, Banff, Aberdeen, Kincardine, Forfar, Perth, and Stirling," appears to us to be very near to, if not identical with *C. sphæroideum* West (1892). Its characters were very briefly indicated by Lundell, and not at all by Messrs. Roy & Bissett, so that it is difficult to make certain of this identity. It should be pointed out that *C. sphæroideum* differs from *C. amœnum* in its somewhat larger dimensions, its greatly inflated semicells, and in the larger and more flattened granules.

Var. **mediolæve** Nordst. (Pl. CII, figs. 5, 6.)

C. amœnum var. *mediolæve* Nordst. in Botan. Notis. 1887, p. 160; Freshw. Alg. N. Zeal. 1888, p. 50, t. 5, f. 12; De Toni, Syll. Alg. 1889, p. 989; West, Alg. W. Ireland, 1892, p. 156; Roy & Biss Scott. Desm. 1894, p. 42; Borge, Süssw.-Chlor. Feuerland u. Is. Desola. 1906, p. 26; G. S. West, Alg. Yan Yean, 1909, p. 64.

Semicells destitute of granules in the median part (or lower median part), with two horizontal series of granules across the base, and with the rest of the granules disposed in decussating oblique series.

Length 45–76 μ; breadth 26–40 μ; breadth of isthmus 9–20 μ.

Scotland.—Dalbrake in Strachan, Kincardine (*Roy & Bissett*).

Ireland.—Ballynahinch, Galway!

Geogr. Distribution.—Australia. New Zealand. Patagonia.

This variety varies much in size, the largest specimens exceeding those of any other form of *C. amœnum*. The granules are smaller than in typical *C. amœnum*, and their disposition is quite different. The clear space in the median part of each semicell is often punctate.

238. **Cosmarium pseudamœnum** Wille. (Pl. CII, figs. 7–9.)

Cosmarium pseudamœnum Wille, Sydamerik. Algfl. 1884, p. 18, t. 1, f. 37; De Toni, Syll. Alg. 1889, p. 996; West, Alg. W. Ireland, 1892, p. 156; Borge, Süssw. Chlor. Archang. 1894, p. 19; Lütkem. Desm. Central China, 1900, p. 119; W. & G. S. West, Alga-fl. Yorks. 1900, p. 89; Alg. N. Ireland, 1902, p. 38; Borge, Alg. erst. Regnell. Exped., II. Desmid. 1903, p. 85; Beiträge Alg. Schweden, 1906, p. 29; G. S. West, Alg. Third Tanganyika Expedit. 1907, p. 123 [forms].

C. inornatum Josh. Burmese Desm. 1886, p. 648, t. 24, f. 26, 27; De Toni, Syll. Alg. 1889, p. 966.

Ursinella pseudamœna Kuntze, Revis. gen. plant. 1891, p. 925.

U. inornata Kuntze, l. c. p. 925.

Dysphinctium pseudamœnum Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 92, t. 4, f. 4, 5. [Schmidle's figures are possibly *C. amœnum*?]

Cells somewhat small, about twice as long as broad, almost cylindrical, only slightly constricted, sinus a small and open notch; semicells oblong with the sides straight or very slightly convex, apex broadly rounded

or faintly truncate in the middle; cell-wall uniformly granulate, granules small and rather variable in disposition, sometimes irregular, sometimes in more or less distinct longitudinal series, and not infrequently in decussating oblique series. Side view of semicell oblong with a rounded apex. Vertical view subcircular-elliptic. Chloroplasts axile, with one pyrenoid (or two ?) in each semicell.

Zygospore unknown.

Length 44–59 μ; breadth 18–29 μ; breadth of isthmus 15–24 μ; thickness 21–25·5 μ.

England.—Skipwith Common, E. Yorks!

Ireland.—Dungloe, near Glenties, Loughs Anna, Claggan, Magrath and Sproule, Donegal! Foxford, Mayo! Clifden and Athry Lough, Galway!

Geogr. Distribution.—Germany. Galicia in Austria. Sweden. Bornholm. Finland. N. Russia. Central China. New Zealand (var.). E. Africa. United States. Brazil.

The distinctions between *C. pseudamœnum* and *C. amœnum* are very slight. The cell of *C. pseudamœnum* is proportionately a little narrower, the constriction is less deep, and only one pyrenoid is present in each semicell; but we are inclined to think the latter character is not constant.

It is a species which requires thorough investigation.

Var. **basilare** Nordst. (Pl. CII, figs. 10–12.)

C. pseudamœnum Wille var. *basilare* Nordst. in Botan. Notis. 1887, p. 160; Freshw. Alg. N. Zeal. 1888, p. 50, t. 5, f. 14; W. & G. S. West, Some Desm. U. S. 1898, p. 308; Borge, Beiträge Alg. Schweden, 1906, p. 29.

Semicells with a transverse double series of granules across the base just above the isthmus, each pair of granules being part of a bigranulate wart.

Length 40–53 μ; breadth 22·5–30 μ; breadth of isthmus 15–22 μ; thickness 18–19 μ.

Scotland.—Near Tarbert, Harris, Outer Hebrides!

Geogr. Distribution.—Sweden. United States. New Zealand.

The double series of basal granules are well marked in this

variety. We have already commented upon the tendency towards the formation of a similar basal zone in certain forms of *C. amœnum*.

239. **Cosmarium latifrons** Lund.

(Pl. XCIV, fig. 6.)

Cosmarium latifrons Lund. Desm. Suec. 1871, p. 30, t. 3, f. 7; De Toni, Syll. Alg. 1889, p. 1011; Roy & Biss. Scott. Desm. 1894, p. 104; Nordst. Index Desmid. 1896, p. 156.
Ursinella latifrons Kuntze, Revis. gen. plant. 1891, p. 925.

Cells small, as long as broad, moderately constricted, sinus very narrow and linear; semicells widely trapeziform, sides upwardly diverging from a broad base, inferior angles obtuse-angled, superior angles slightly rounded, apex wide and convex; cell-wall finely granulate except in the centre of each semicell, the margin having a finely serrate appearance, in the centre with a small protuberance furnished with three vertical series of larger granules. Side view of semicell ovate, with a granulate inflation near the base on each side. Vertical view elliptic, with a small trigranulate inflation at the middle on each side, granulate except for an elliptic, smooth area in the centre. Chloroplasts axile, with one pyrenoid in each semicell.

Zygospore unknown.

Length 34–38 μ; breadth 34–38 μ; breadth of isthmus 15 μ; thickness 23·3 μ.

Scotland.—Barrelwell Moss near Brechin, Forfar (*Roy & Bissett*).

Geogr. Distribution.—Galicia in Austria. Norway. Sweden. N. Russia (a form). Siberia.

C. latifrons is a small species somewhat resembling certain forms of *C. biretum* in external shape, but with very distinctive characters.

240. **Cosmarium lepidum** West.

(Pl. XCIV, fig. 10.)

Cosmarium lepidum West, Alg. N. Yorks. 1889, p. 292, t. 291, f. 14; Roy & Biss. Scott. Desm. 1894, p. 105; Nordst. Index Desm. 1896, p. 157; W. & G. S. West, Alga-fl. Yorks. 1900, p. 89.

Cells very small, subquadrate, about as long as broad, deeply constricted, with a linear sinus; semicells transversely rectangular with straight sides and apex, basal and apical angles scarcely rounded, apical angles sometimes very slightly produced; cell-wall uniformly granulate giving the margins a minutely crenulate appearance, granules disposed in transverse rows, three of which are visible across the front of each semicell. Side view of semicell circular. Vertical view elliptic, ratio of axes about 1 : 1·7.

Zygospore unknown.

Length 16–17·5 μ; breadth 17–18·5 μ; breadth of isthmus 6·5–7 μ; thickness 10 μ.

England.—Mickle Fell, N. Yorks!

Scotland.—Ben Chiurn, Perth!

241. **Cosmarium promontorium** W. & G. S. West. (Pl. XCIV, fig. 9.)

Cosmarium promontorium W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 7, t. 1, f. 14; Nordst. Index Desmid. 1896, p. 206.

Cells small, about 1⅓ times longer than broad, deeply constricted, sinus narrowly linear with a dilated extremity; semicells broadly subrectangular, with the sides more or less irregularly biundulate, with three crests (including the basal and apical angles) and two hollows, the upper hollow being deeper than the lower one, basal angles rounded, apical angles subacute and prominent, apex convex but widely truncate in the middle; with one series of minute granules just within the margin of each semicell, about four within each lateral margin and four within the apex. Side view of semicell rounded-ovate, with the upper part of the sides slightly retuse. Vertical view elliptic, with a small inflation at the middle on each side. Chloroplasts axile, with one pyrenoid in each semicell.

Zygospore unknown.

Length 22 μ; breadth 17 μ; breadth of isthmus 3·5 μ; thickness 10·5 μ.

Ireland.—Oorid Lough, Galway!

242. **Cosmarium crenatum** Ralfs.

(Pl. XCVIII, figs. 9–12.)

Cosmarium crenatum Ralfs in Ann. Mag. Nat. Hist. 1844, p. 394, t. 11, f. 6 [in part]; Hass. Brit. Freshw. Alg. 1845, p. 365; Ralfs, Brit. Desm. 1848, p. 96, t. 15, f. 7 *b* and *c* [not 7 *a*]; Arch. in Pritch. Infus. 1861, p. 732; De Not. Desm. Ital. 1867, p. 47, t. 4, f. 34; Rabenh. Flor. Europ. Alg. III, 1868, p. 165; Lund. Desm. Succ. 1871, p. 34; Nordst. Desm. Spetsb. 1872, p. 29, t. 6, f. 7, 8; Desm. Arctoæ, 1875, p. 38; Alg. aq. dulc. et Char. Sandvic. 1878, p. 12; Kirchn. Alg. Schles. 1878, p. 149; Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 40; Boldt, Siber. Chlorophy. 1885, p. 105; Cooke, Brit. Desm. 1886, p. 95, t. 37, f. 13; Hansg. Prodr. Algenfl. Böhm. 1888, p. 195; De Toni, Syll. Alg. 1889, p. 941; West, Alg. N. Yorks. 1889, p. 292; Alg. N. Wales, 1890, p. 289; Alg. W. Ireland, 1892, p. 150; Alg. Engl. Lake Distr 1892, p. 726; Borge, Chlor. Norska Finmark. 1892, p. 10; Lütkem. Desm. Attersees, 1893, p. 553; Borge, Süssw. Chlor. Archang. 1893, p. 21; Börg. Freshw. Alg. Östgrönl. 1894, p. 14; Roy & Biss. Scott. Desm. 1894, p. 44; Gutw. Flor. Glon. Okolic Tarnapola, 1894, p. 86; Schmidle, Beitr. alp. Alg. 1895, p. 388; Nordst. Index Desmid. 1896, p. 87; W. & G. S. West, Alg. S. England, 1897, p. 488; W. & G. S. West, Alga-fl. Yorks. 1900, p. 89; Börg. Freshw. Alg. Færoës, 1901, p. 227; Borge, Süsswasseralgen Süd-Patagon. 1901, p. 22; Bohlin, Flor. Algol. d'eau douce d. Açores, 1901, p. 65; W. & G. S. West, Alg. N. Ireland, 1902, p. 37; Hirn, Desm. Finland, 1903, p. 8; Borge, Alg. erst. Regnell. Exped., II. Desmid. 1903, p. 92; Larsen, Freshw. Alg. E. Greenland, 1904, p. 84; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 22; Borge, Beiträge Alg. Schweden, 1906, p. 34; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 177.

Euastrum crenatum Gay, Monogr. loc. Conj. 1884, p. 60. [not *E. crenatum* Focke, Phys. Stud. 1847, p. 41, t. 1, f. 3, which = *Cosmarium ortogonum* Delp.; nor *E. crenatum* Näg. Gatt. einz. Alg. 1849, p. 120, t. 7 A, f. 8, which = *Cosm. Naegelianum* Bréb.; nor *E. crenatum* Perty, 1852, which = *Cosm. dovrense* Nordst.]

Cosmarium crenatum forma *tricrenata* Boldt, Siber. Chlorophy. 1885, p. 105.

C. crenatum a. *Ralfsiana* Racib. Nonn. Desm. Polon. 1885, p. 76.

C. crenatum e. *major* Racib. l. c.

Ursinella crenata Kuntze, Revis. gen. plant. 1891, p. 924.

Cosmarium crenatum var. *psychophilum* Schmidle, Lappmark Süsswasseralgen, 1898, p. 29.

C. crenatum forma *sublævis* Schmidle, l. c. p. 29.

C. ordinatum Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 333, t. 7, f. 11. [not *C. ordinatum* (Börg.) W. & G. S. West, 1896].

Cells rather small, $1\frac{1}{5}$–$1\frac{1}{2}$ times as long as broad, moderately deeply constricted, sinus linear but not quite closed; semicells pyramidate-quadrate, with the basal angles rectangular and slightly rounded, sides 3-crenate (or more rarely 4-crenate), apex truncate and 4-crenate, with 1–3 smaller subsidiary crenulations within each lateral and apical crenation, internal crenulations smooth or furnished with one or two

minute granules, in the centre with 3–6 vertical costæ, sometimes smooth and indistinct, more rarely indistinctly granulate. Side view of semicell rectangular, basal angles slightly tumid, sides and apex faintly retuse, apical angles minutely granulate. Vertical view elliptic, with a broad 3–6-undulate inflation at each side, poles subtruncate and minutely granulate. Chloroplasts axile, with one pyrenoid in each cell.

Zygospore globose, furnished with many stout verrucæ (about 16 visible at the margin), slightly attenuated and 2-, 3- or 4-furcate at the apex.

Length 27–43 (rarely to 59) μ; breadth 22–31 (rarely to 44) μ; breadth of isthmus 9–13 μ; thickness 14–22 (rarely to 28) μ; diam. zygosp. without verrucæ 29 μ, with verrucæ 38 μ.

England.—Cumberland! Westmoreland! Lancashire (*Ralfs*). W. and N. Yorks! Sub-fossil at Filey, E. Yorks! Leicestershire (*Roy*). Gloucestershire (*Ralfs*). Surrey! Sussex, Hants, and Wilts! (*Ralfs*). Devonshire! Cornwall!

Wales.—Llyn Teyrn on Snowdon, Penmaenmawr, Moelfre, near Dolbadarn Castle, Bethesda, Capel Curig (*Cooke & Wills*), Moel Siabod, and Llyn Cwlyd, Carnarvonshire! Merionethshire! Glamorganshire!

Scotland.—Common; zygospores from Muchalls, Kincardine, and Rannoch, Perth (*Roy & Bissett*). At 3500 ft. on Lochnagar! Orkneys! Shetlands! Outer Hebrides!

Ireland.—Donegal! Galway! Kerry! Dublin and Wicklow (*Archer*). Down (up to 2000 ft.)!

Geogr. Distribution.—France. Germany. Austria and Galicia. Bosnia. Hungary. Roumania. Italy. Norway. Sweden. Denmark. Bornholm. Finland. N. and S. Russia. Faeroes. Iceland. Nova Zembla. Spitzbergen. Greenland. Siberia. Japan. India. Australia. Abyssinia. E. Africa. Azores. Sandwich Islands. United States. Brazil. Ecuador. Argentine. Patagonia.

C. crenatum is largely an alpine and arctic Desmid. In

mountainous areas it is not uncommon in boggy springs and amongst mosses on dripping rocks. In more lowland districts it is principally confined to ancient heaths.

The common British form has three crenations at each side of the semicell and four at the apex. Specimens are not uncommon, however, with four crenations at each side, the lower one being very variable in size, so that we have found it impossible to draw any clear distinction between those forms with three lateral crenations and those with four. The lateral and apical crenations, as in so many Desmids, are merely the optical expression of ridges which run across the cell transversely to the greatest breadth. These ridges are themselves broken up into hummocks, so that one or two series of crenations may often be focussed within the marginal ones. Sometimes each crenation is minutely bigranulate, but this is by no means a constant character even in the two halves of the same cell. The vertical ribs in the centre of the semicell are also very variable, sometimes being scarcely evident and at other times more or less distinctly granulated.

After a careful consideration of the variation exhibited by *C. crenatum* we have been compelled to include within the general description of the species Boldt's forma *tricrenata* and Schmidle's var. *psychophilum* (founded upon Nordstedt's Spitzbergen forms) and var. *sublævis*.

It should also be mentioned that *C. crenatum* varies much both in size and in general proportions.

Forma **Boldtiana** (Gutw.) *nob.* (Pl. XCVIII, figs. 13, 14.)

Cosmarium Boldtianum Gutw. Flor. Glon. Okolic Tarnapola, 1894, p. 100 t. 3, f. 36; Schmidle, Alg. aus Sumatra, 1895, p. 304.
C. tricrenatum Gutw. Prodr. Flor. Alg. Galic. 1895, p. 351.

Semicells with 5 or 6 crenations on each lateral margin, the two lowest ones often much reduced in size.

Length 29–42 μ; breadth 22–28 μ; breadth of isthmus 10–14 μ; thickness 10–18 μ.

Scotland.—Not uncommon, but scarce (*Roy & Bissett*).

Geogr. Distribution.—Galicia in Austria. Sumatra.

This form only differs from the more typical forms in its lateral crenations. It was originally figured by Ralfs ('Brit. Desm.' 1848, t. 15, f. 7*a*).

Var. **bicrenatum** Nordst. (Pl. XCVIII, fig. 15.)

C. crenatum var. *bicrenatum* Nordst. Desm. Spetsb. 1872, p. 30, t. 6, f. 10; Desm. Ital. 1876, p. 35; Boldt, Desmid. Grönland, 1888, p. 18; Roy & Biss. Scott. Desm. 1894, p. 44.

C. bicrenatum Joshua, Notes Brit. Desm. II, 1883, p. 291; Cooke, Brit. Desm. 1886, p. 96, t. 42, f. 13.

Semicells with only two lateral crenations.

Length 24–33 μ; breadth 17·5–26 μ; breadth of isthmus 9·5–11 μ; thickness 12–15 μ.

England.—Leicestershire (*Roy*).

Scotland.—Not uncommon, but scarce (*Roy & Bissett*).

Geogr. Distribution.—Italy. Norway. Nova Zembla. Spitzbergen. Greenland. Siberia.

243. **Cosmarium Grantii** Roy & Biss.

(Pl. XCI, fig. 11.)

Cosmarium Grantii Roy & Biss. Scott. Desm. 1894, p. 102, t. 1, f. 10; Nordst. Index Desm. 1896, p. 134.

Cells small, almost as long as broad, deeply constricted, sinus linear; semicells subsemicircular-rectangular, basal angles scarcely rounded, margin 12-crenate, four up each side and four at each apex, the three lower lateral crenations rather smaller than the others, with a radiating series of about six very minute binate granules within each crenation, and in the middle immediately above the isthmus with two horizontal series of conspicuous granules, five in each series. Side view of semicell subquadrate, basal and apical angles rounded, sides slightly retuse in the upper portion, apex truncato-convex, with two granules on each side just above the isthmus. Vertical view elliptic-oblong, with a broad inflation at the middle on each side.

Zygospore unknown.

Length 34–35 μ; breadth 30–31 μ; breadth of isthmus 13–14 μ; thickness 15–16 μ.

Scotland.—Glassel and Slewdrum, Aberdeen; Letterbeg in Strachan, Kincardine (*Roy & Bissett*).

We have not yet seen this species, which Messrs. Roy and Bissett state has only been observed on wet rocks.

244. **Cosmarium annulatum** (Näg.) De Bary.

(Pl. CII, figs. 13–15.)

Dysphinctium (*Calocylindrus*) *annulatum* Näg. Gatt. einzell. Alg. 1849, p. 110, t. 6 F; Reinsch, Algenfl. Frank. 1867, p. 181; Hansg. Prodr. Algenfl. Böhm. 1888, p. 186; De Toni, Syll. Alg. 1889, p. 887; Heimerl, Desm. alp. 1891, p. 594; Hirn, Desm. Finland, 1903, p. 14.

Cosmarium annulatum (Näg.) De Bary, Conj. 1858, pp. 46, 72; Lund. Desm. Suec. 1871, p. 46; Nordst. Desm. Arctoæ, 1875, p. 30; Alg. aq. dulc. et Char. Sardvic. 1878, p. 14; Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 49; Boldt, Siber. Chlor. 1885, p. 108; Desmid. Grönland, 1888, p. 29; Börg. Desm. Brasil. 1890, p. 42; West, Alg. W. Ireland, 1892, p. 157; W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 7, t. 2, f. 42; Börg. Freshw. Alg. Östgrönl. 1894, p. 22; W. & G. S. West, Alg. S. England 1897, p. 492; Bohlin, Flor. Algol. d'eau douce d'Açores, 1901, p. 66; W. & G. S. West, Alg. N. Ireland, 1902, p. 42.

Penium annulatum Arch. in Pritch. Infus. 1861, p. 51; Rabenh. Flor. Europ. Alg. III, 1868, p. 122; Lütkemüll. Desm. Attersees, 1893, p. 544.

Calocylindrus annulatus Kirchn. Alg. Schles. 1878, p. 143; Cooke, Brit. Desm. 1887, p. 122, t. 43, f. 15.

Cells rather small, subcylindrical, 2–2¼ times as long as broad, scarcely constricted, sinus not evident; semicells rectangular, sides 4–5-undulate including the apical angle, apex convexo-truncate, with 4–5 transverse series of small nodules (5–6 in each series) corresponding to the marginal undulations. Vertical view circular, with about 14 marginal undulations (or nodulations). Chloroplasts . . . . ?, with two transversely-disposed pyrenoids in each semicell.

Zygospore unknown.

Length 36–54 μ; breadth 16–23 μ; breadth of isthmus 14·5–21 μ.

England.—Westmoreland (*Bissett*). Cornwall (*Marquand*). Tintagel, Cornwall!

Wales.—Llyn Cwlyd, Carnarvonshire!

Scotland.—Ross, Aberdeen, Kincardine, and Perth (*Roy & Bissett*). Shetlands!

Ireland.—Nacoogarrow Lough, Galway! Carrantuohill, Kerry! Adrigole, Cork! Dublin and Wicklow (*Archer*). Slieve Donard, Down!

Geogr. Distribution.—France. Germany. Austria and Galicia. Hungary. Italy. Norway. Sweden.

Denmark. Bornholm. Finland. S. Russia. Nova Zembla. Franz Joseph Land. Spitzbergen. Greenland. New Zealand (var.). Sandwich Islands. West Indies. Brazil.

This characteristic species occurs mostly on wet rocks. It requires further investigation, especially of living specimens, as there is much doubt concerning the nature of its chloroplasts, and its position in the genus *Cosmarium* is by no means certain.

Var. **elegans** Nordst (Pl. CII, figs. 16–18.)

C. annulatum var. *elegans* Nordst. Norges Desm. 1873, p. 23; Desm. Ital. 1876, p. 42; West, Alg. Engl. Lake District, 1892, p. 728; W. & G. S. West, Further Contrib. Freshw. Alg. W. Indies, 1899, p. 284; Börg. Freshw. Alg. Færoës, 1901, p. 228; W. & G. S. West, Alg. N. Ireland, 1902, p. 42; Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Borge, Beiträge Alg. Schweden, 1906, p. 36.

Crenations distinctly but minutely bigranulate. Length 40–57·5 μ; breadth 17–29 μ.

England.—Borrowdale, Cumberland! Blea Tarn and Pike of Bliscoe, Westmoreland! Hawkshead, Lancashire!

Wales.—Moel Siabod!, Pen-y-gwryd (*Roy*), and Glyder Fach!, Carnarvonshire.

Scotland.—Aberdeen, Kincardine, Forfar, and Perth (*Roy & Bissett*). Kirkcudbright!

Ireland.—Dublin and Wicklow (*Archer*). Slieve Donard and Slieve Commedagh, Down!

Geogr. Distribution.—Norway. Sweden. Faeroes. Italy. West Indies.

C. annulatum var. *elegans* appears to be widely distributed, and is a much prettier Desmid than the type. It is at once distinguished from all forms of *C. elegantissimum* by its broadly truncate, smooth apex, and by the scarcely evident median constriction.

245. **Cosmarium elegantissimum** Lund. (Pl. CII, fig. 19.)

Cosmarium elegantissimum Lund. Desm. Suec. 1871, p. 53, t. 3, f. 20; Wolle, Desm. U. S. 1884, p. 78, t. 14, f. 8–9; Johnson, Rare Desm. U. S. II, 1895, p. 292, t. 240, f. 27; Nordst. Index Desmid. 1896, p. 116.
Cosmaridium elegantissimum Hansg. Prodr. Algenfl. Böhm. 1886, p. 246.
Pleurotæniopsis elegantissima De Toni, Syll. Alg. 1889, p. 909.

Cells rather under medium size, about $2\frac{1}{2}$ times longer than broad, perfectly cylindrical with hemispherical ends, median constriction very slight, sinus a slight excavation; semicells oblong, with a rectangular base, apex strongly convex. Cell-wall furnished with emarginate verrucæ (about 19 visible round the margin of a semicell), disposed in regular vertical and horizontal series, about 8 or 9 horizontal series and about 9 vertical series seen in front view. Vertical view circular, with about 22 small nodulations round the margin. Chloroplasts parietal, in three bands enclosing two pyrenoids in each semicell.

Zygospore unknown.

Length 82–88 μ; breadth 33–37 μ; breadth of isthmus 24–27 μ.

Wales.—Capel Curig, Carnarvonshire (*Roy & Bissett*).

Ireland.—Derryclare Lough, Galway!

Scotland.—Moidart, Inverness! Powlair and Slewdrum, Aberdeen; Near Bridge of Bogandreep and Blackhall in Strachan, Kincardine; Glen Garry (*Roy & Bissett*), Ben Lawers, and Loch Katrine, Perth!

Geogr. Distribution.—Sweden. Bohemia in Austria. United States.

Forma **minor** West. (Pl. CII, figs. 20, 21.)

C. elegantissimum Lund. forma *minor* West, Alg. W. Ireland, 1892, p. 164, t. 24, f. 10; Alg. Engl. Lake District, 1892, p. 730; W. & G. S. West, Alg. S. England, 1897, p. 492 [recorded as type]; Borge, Trop. u. subtrop. Süssw.-Chlor. 1899, p. 19; W. & G. S. West, Alga-fl. Yorks. 1900, p. 94 [recorded as type].

Cells less than two-thirds the size of the typical form.

Length 49–54 μ; breadth 22–23 μ; breadth of isthmus 17–19·5 μ.

England.—Borrowdale, Cumberland! Bowness and Helvellyn, Westmoreland! Near Cockley Beck, Lancashire! Pilmoor, N. Yorks! Skipwith Common, E. Yorks! Thursley Common, Surrey! New Forest, Hants!

Wales.—Yr Orsedd, Carnarvonshire!

Scotland.—Sutherland! Harris and Lewis, Outer Hebrides!

Ireland.—Achill Island, Mayo! Carrantuohill, Kerry!

Geogr. Distribution.—Uruguay.

This small form appears to be more frequent than the type. It somewhat resembles *C. annulatum* var. *elegans*, but the horizontal series of bigranulate warts are situated closer together, and the convex, verrucose apex is quite distinctive.

We have described from the United States a var. *simplicius* of *C. elegantissimum* in which the warts are entire, rounded elevations (Cf. W. & G. S. West, 'Some Desm. U. S.' 1898, p. 308, t. 17, f. 7). This form also has the hemispherical poles so characteristic of all forms of *C. elegantissimum*.

246. **Cosmarium tuberculatum** Arch.

(Pl. XCVII, figs. 9–11.)

Cosmarium tuberculatum Arch. Descript. New Cosm., etc., 1863, p. 247, t. 12, f. 11–15; Rabenh. Flor. Europ. Alg. III, 1868, p. 178; Roy & Biss. Scott. Desm. 1894, p. 177; W. & G. S. West, Alga-fl. Yorks. 1900, p. 95.
Calocylindrus tuberculatus (Arch.) Cooke, Brit. Desm. 1887, p. 123, t. 43, f. 15; West, Alg. N. Yorks. 1889, p. 293.
Disphinctium tuberculatum De Toni, Syll. Alg. 1889, p. 892.

Cells minute, about $1\frac{1}{4}$ times longer than broad, moderately constricted, sinus widely open and shallow, forming an obtuse angle; semicells elliptic-hexagonal, the upper convex margin bordered by 5–7 (usually 6) minute and rather depressed granules. Side view of semicell ovate-elliptic, with the upper convex margin furnished with 5–6 granules. Vertical view broadly elliptic, with 6–7 granules round the margin. Chloroplasts . . . . ?

Zygospore unknown.

Length 15–18·5 μ; breadth 12–14 μ; breadth of isthmus 7–8 μ; thickness 7·5–8·5 μ.

England.—Mickle Fell, N. Yorks!

Scotland.—Scotston Moor, Aberdeen; Durris, Kincardine; between Loch Lomond and the head of Loch Long, Dumbarton (*Roy & Bissett*).

Ireland.—Dublin and Wicklow (*Archer*).

We have only observed this minute species on one occasion. Its outward form and granulation are very characteristic.

247. **Cosmarium cylindricum** Ralfs.

(Pl. XCIV, fig. 7.)

Cosmarium cylindricum Ralfs in Ann. Mag. Nat. Hist. xiv, 1844, p. 392, t. 11, f. 1; Hass. Brit. Freshw. Alg. 1845, p. 365, t. 86, f. 4; Ralfs, Brit. Desm. 1848, p. 106, t. 17, f. 4; Arch. in Pritch. Infus. 1861, p. 734, t. 3, f. 16–17; Rabenh. Flor. Europ. Alg. III. 1868, p. 176; Wille, Norges Ferskv. Alg. 1880, p. 36; Cooke, Brit. Desm. 1887, p. 122, t. 43, f. 1–4; West, Alg. W. Ireland, 1892, p. 157; Alg. Engl. Lake District, 1892, p. 728; Nordst Index Desm. 1896, p. 95; Borge, Beiträge Alg. Schweden, 1906, p. 29.

Penium Ralfsii Kütz. Spec. Alg. 1849, p. 167; Delp. Desm. subalp. 1877, p. 90, t. 15, f. 26–28.

Dysphinctium ? cylindricum Reinsch, Algenfl. Franken, 1867, p. 181; Turn. Freshw. Alg. E. India, 1893, p. 44.

Calocylindrus Ralfsii Kirchn. Alg. Schles. 1878, p. 142.

Calocylindrus cylindricus (Ralfs) Racib. in Spraw. Kom. fizyjogr. Akad. Um Krakow. 1884, p. 9 (= a. *typica* Racib.); Cooke, Brit. Desm. 1887, p. 122, t. 43, f. 1–4; West, Alg. N. Wales, 1890, p. 291.

Disphinctium Ralfsii Hansg. in Österr. bot. Zeitschr. XXXVII, 1887, p. 99; Prodr. Algenfl. Böhm. 1888, p. 186; De Toni, Syll. Alg. 1889, p. 888.

Cells rather small, subcylindrical, a little more than twice as long as broad, very slightly constricted; semicells subrectangular or subquadrate, with the sides slightly divergent, apical angles rounded, apex convex-truncate. Cell-wall furnished with small granules rather densely arranged in somewhat indefinite longitudinal series, 25–27 visible round the margin of a semicell. Vertical view circular. Chloroplasts . . . . ?

Zygospore unknown.

Length 38–57 μ; breadth 19–24 μ; breadth of isthmus 15–17 μ.

England. — Helvellyn, Westmoreland! Sussex (*Ralfs*). Kent (*Ralfs*). Cornwall (*Ralfs*).

Wales.—Llyn Padarn!, and Capel Curig! (*Cooke & Wills*), Carnarvonshire. Machynlleth, Montgomery (*Ralfs*).

Scotland.—Aberdeen, Kincardine, Forfar, Perth, Arran (*Roy & Bissett*).

Ireland.—Athry Lough, Galway! Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Poland. Austria. Italy. Norway. Sweden. N. and S. Russia. Nova Zembla. United States. India.

This rather rare Desmid requires further investigation, especially with regard to the nature of the chloroplasts. It is not at all certain in the present state of our knowledge whether it should be placed in the genus *Cosmarium* or in the genus *Penium*.

248. **Cosmarium subcylindricum** West.

(Pl. XCIV, fig. 8.)

Cosmarium subcylindricum West, Alg. Engl. Lake Distr. 1892. p. 728, t. 9, f. 22; Nordst. Index Desm. 1896, p. 244.

Cells small, about $1\frac{3}{4}$ times longer than broad, slightly constricted; semicells semi-elliptic, with the sides almost straight. Cell-wall densely granulate, granules small and indefinitely disposed, with a single transverse ring of larger granules at the base of each semicell and immediately next the isthmus. Vertical view circular.

Zygospore unknown.

Length 37 μ; breadth 21 μ; breadth of isthmus 18 μ.

England.—Loughrigg, Westmoreland!

This Desmid differs from *Cosmarium cylindricum* in the shape of its semicells, especially the rounded poles, in the irregular arrangement of the small granules, and in the ring of larger granules at the base of each semicell. We have only seen it on one occasion.

Addenda to Genus *Cosmarium*.

249. **Cosmarium basilicum** G. S. West.

(Pl. CIII, fig. 1.)

Cosmarium basilicum G. S. West, Alga-fl. Cambr. 1899, p. 218, t. 396, f. 7; Nordst. Index Desmid. Suppl. 1908, p. 29.

Cells of medium size, about $1\frac{1}{4}$ times longer than broad, deeply constricted, sinus narrowly linear with

a very strongly dilated apex; semicells subsemicircular, basal angles subrectangular and slightly rounded, apex very slightly flattened. Cell-wall granulate; granules rather distant and arranged in somewhat irregular oblique series, slightly diminishing in size towards the centre of each semicell; above the isthmus with 3 rather irregular transverse series of small granules, about 5 or 6 in each series; between the granules minutely and densely punctate. Side view of semicell circular. Vertical view elliptic with rounded poles, ratio of axes 1 : 1·5.

Zygospore unknown.

Length 79 μ; breadth 65 μ; breadth of isthmus 17 μ; thickness 39 μ.

England.—Chippenham Fen, Cambridgeshire!

This species has the same outward form as *C. radiosum* Wolle, but is otherwise very different from it. It should be compared with *C. dentiferum* Corda, and with forms of *C. margaritiferum*.

250. **Cosmarium taxichondrum** Lund.

(Pl. CIII, figs. 11–13).

Cosmarium taxichondrum Lund. Desm. Suec. 1871, p. 39, t. 2, f. 13; Wille. Norges Ferskv. Alg. 1880, p. 32; Wolle, Desm. U. S. 1884, p. 71, t. 16, f. 32–34; Lagerh. Bidr. Amerik. Desm.-fl. 1886, p. 237; Hansg. Prodr. Algenfl. Böhm. 1888, p. 197; De Toni, Syll. Alg. 1889, p. 990; Borge, Süssw. Chlor. Archang. 1894, p. 31; W. & G. S. West, Alg. Madag. 1895, p. 66, t. 7, f. 2; Nordst. Index Desmid. 1896, p. 250; Cushman in Bull. Torr. Bot. Club, xxxii, 1905, p. 551; Borge, Beiträge Alg. Schweden, 1906, p. 42.

C. taxichondrum a genuina Racib. Desm. Nowje, 1889, p. 88.

Ursinella taxichondra Kuntze, Revis. gen. plant. 1891, p. 925.

Cells rather small, a little longer than broad, very deeply constricted, sinus linear and slightly undulated; semicells semicircular, with the basal angles slightly thickened and giving a faint impression of being directed downwards, apex slightly flattened or subtruncate; cell-wall punctate, furnished with a prominent granule in the median part of the semicell immediately above the isthmus, and with two transverse arcuate series of granules in the upper median region of the

semicell, 3 in the upper series (just within the apex) and 5–6 in the lower series. Side view of semicell circular, with 3 prominent granules on each side. Vertical view elliptic, poles somewhat conical, with 5–6 granules at the median part of each side and 3 others within them. Chloroplasts axile, with two pyrenoids in each semicell.

Zygospore unknown.

Length 36–50 μ; breadth 32·5–45 μ; breadth of isthmus 9–14 μ; thickness 19–24 μ.

Scotland.—Rhiconich, Sutherland!

Geogr. Distribution.—Bohemia in Austria. Hungary. Norway. Sweden. Poland. N. Russia. Siberia (var.) China. Japan (var.). India. Ceylon (var.). Java. Madagascar (and vars.). Abyssinia. Central Africa (var.). United States (and vars.).

C. taxichondrum is a very rare British species, and is only known to occur in these islands in its typical form. In tropical and subtropical countries it is, however, much more abundant, and exhibits considerable variation. There are about fourteen named varieties, some of which are very characteristic and retain fairly constant characters.

251. **Cosmarium prominulum** Racib.

(Pl. CIII, fig. 2.)

Cosmarium prominulum Racib. Nonn. Desm. Polon. 1885, p. 79, t. 11, f. 7; De Toni, Syll. Alg. 1889, p. 1004; West, Alg. W. Ireland, 1892, p. 149; Lütkem. Desm. Attersees, 1893, p. 550; Roy & Biss. Scott. Desm. 1894, p. 172; Nordst. Index Desmid. 1896, p. 206.
Ursinella prominula Kuntze, Revis. gen. plant. 1891, p. 925.

Cells very small, as long as broad, deeply constricted, sinus open with a rounded extremity; semicells subhexagonal, twice as wide as their height, lateral angles obtusely mamillate, apex widely truncate, within each lateral angle with a very small protuberance. Side view of semicell rhomboid, lateral angles and apex rounded, upper sides concave. Vertical view rhomboid-elliptic, with a large tumour at the middle on each side, and a very small one on each side close to

the poles. Cell-wall smooth. Chloroplasts axile, with one central pyrenoid in each semicell.

Zygospore unknown.

Length 13–18 μ; breadth 14–18 μ; breadth of isthmus 6–7·5 μ; thickness 9–12 μ.

Scotland.—Poolewe, Ross; Brin, Inverness (*Roy & Bissett*).

Ireland.—Glen Caragh, Kerry!

Geogr. Distribution.—Austria and Galicia.

This species should be compared with *Cosmarium monochondrum* Nordst., from which, however, it is easily distinguished.

Var. **subundulatum** W. & G. S. West. (Pl. CIII, fig. 3.)

C. prominulum var. *subundulatum* W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 6, t. 1, f. 16.

Semicells with the apex slightly 3–4-undulate, and with the superior lateral margins biundulate (one crest and two hollows); vertical view with a more conical median protuberance on each side, with the tumours near the poles larger, and with the poles more markedly mamillate.

Length 16–18 μ; breadth 17–19 μ; breadth of isthmus 8–9·5 μ; thickness 13·5 μ.

England.—Elter Water, Cumberland!

Lütkemüller has described from Austria ('Desm. Millstättersees,' 1900, p. 10, t. 1, f. 28–30) a forma *ornata* of this variety, to which is also referable the Desmid described by Messrs. Eichler & Gutwinski as *Cosmarium sculptum* (*vide* Eichler & Gutw. 'Nonn. spec. alg. nov.' 1894, p. 169, t. 4, f. 22).

Species to be Enquired into.

Cosmarium cruciatum Bréb. Liste Desm. 1856, p. 129, t. 1, f. 14; Rabenh. Flor. Europ. Alg. III, 1868, p. 168; Kirchn. Alg. Schles. 1878, p. 153; Wolle, Desm. U. S. 1884, p. 81. t. 18, f. 23, 24; Hansg. Prodr. Algenfl. Böhm. 1888, p. 201, 251; De Toni, Syll. Alg. 1889, p. 1014; Roy & Biss. Scott, Desm. 1894, p. 44; Nordst. Index Desmid. 1896, p. 90.

Ursinella cruciata Kuntze, Revis. gen. plant. 1891, p. 924. Cells small, about as long as broad, deeply constricted, sinus narrow, widening outwards; semicells truncate-pyramidate, inferior angles broadly rounded, apices broadly truncate, margin slightly crenate. Vertical view elliptic, with a small submamillate protuberance at the middle on each side. Side view subcircular, with a small protuberance on each side. Cell-wall finely granulate. Chloroplasts axile, with two pyrenoids in each cell.

The above description is based upon the indifferent figures of Brébisson and of Wolle. Messrs. Roy and Bissett have recorded *C. cruciatum* from Scotland as "Not common. Alford, Aberdeen; Cammie, Cowie, etc., Kincardine." We are inclined to regard Brébisson's figure as belonging to some form of *C. punctulatum*, a variety of which (var. *brasiliense* Nordst.) possesses two pyrenoids in each semicell. Nordstedt (*in litt.*, July, 1907) writes "I have never seen any Desmid which I could identify with the figure of *C. cruciatum* Bréb."

Cosmarium Turpinii Bréb. var. cambricum Joshua, New and Rare Desm. 1885, p. 35, t. 254, f. 8. Joshua's figure is a very poor one, but we believe this Desmid to be most probably identical with *C. didymoprotupsum* W. & G. S. West (Consult Vol. III, p. 192, t. 88, f. 8).

Genus 16. **XANTHIDIUM** Ehrenb. 1837.

Ehrenb. in Abh. Berlin. Akad. 1837 [1836], p. 114; Infus. 1838, p. 146.
Menegh. Synops. Desm. 1840, p. 223.
Kütz. Phyc. gener. 1843, p. 162.
Hass. Brit. Freshw. Alg. 1845, p. 358.
Ralfs, Brit. Desm. 1848, p. 111.
Kütz. Spec. Algar. 1849, p. 177.
Arch. in Pritch. Infus. 1861, pp. 720, 735.
Rabenh. Flor. Europ. Alg. III, 1868, p. 221.
Lund. Desm. Suec. 1871, p. 74.
Kirchn. Alg. Schles. 1878, p. 154.
Wolle, Desm. U. S. 1884, p. 92.
Cooke, Brit. Desm. 1887, p. 129.
Boldt, Desmid. Grönland, 1888, p. 31.
De Toni, Syll. Alg. 1889, pp. 905, 916.
Turner, Freshw. Alg. E. India, 1893, p. 103.
G. S. West, Treatise Brit. Freshw. Alg. 1904, p. 168.
Wille in Engler & Prantl, Natürlich Pflanzenfam. 1909, p. 9.
Holacanthum (Lund.) Wille in Engler & Prantl, Natürlich Pflanzenfam. 1890, I, 2, pp. 7, 11. [=Subgen. *Holacanthum* Lund. Desm. Suec. 1871, p. 75].
Schizacanthum (Lund) Wille, l. c. p. 11 [=Subgen. *Schizacanthum* Lund, 1871].

Cells of very variable size, usually somewhat longer than broad, *invariably compressed* (except in the rare triangular forms), symmetrical in three planes at right angles to each other; *median constriction invariably deep;* semicells of variable outline, elliptical, elliptic-hexagonal, trapeziform, or polygonal, generally with a flattened apex, *centre of the semicell* (with rare exceptions) *differentiated as a thickened, often scrobiculated, and generally protuberant area;* vertical view more or less elliptic, *generally with a protuberance at the middle on each side. Cell-wall furnished with simple, or more rarely with furcate spines*, sometimes disposed in a median plane, but *usually arranged more or less symmetrically on each side of a median plane.* Chloroplasts generally parietal, arranged in four cushions in each semicell, each with one or more pyrenoids, but often irregular, partly parietal and partly axile; chloroplasts axile in many of small species, with a single central pyrenoid in each semicell.

Zygospores globose, usually furnished with simple or furcate spines of variable length, more rarely spineless and conspicuously scrobiculate.

The genus *Xanthidium* is distinguished by the compressed cells, the symmetrical, and generally paired, arrangement of spines, and by the differentiated central area of the semicells. The last character is one of the most important features of the genus, although it is often very slight, and is entirely absent in a few forms (such as *X. antilopæum* var. *lævе*, *X. controversum*, and *X. cristatum* var. *leiodermum*). The differentiated region may take the form of a thickened area, with or without scrobiculations, or of a protuberance of variable size, which may be entire, granulate, dentate, or spinate.

The genus is nearly related to *Cosmarium*, *Arthrodesmus*, and *Staurastrum*, from the first of which the majority of the species may have been evolved. It is mostly in the tropics that transitional species occur which connect the genera *Cosmarium* and *Xanthidium*. Turner remarks about the Indian species *Xanthidium cosmariforme* that "this might just as correctly be called *Cosmarium xanthidiforme*."

Lundell, in 1871, instituted the two subgenera *Schizacanthum* and *Holacanthum*, the former to include the species

with furcate spines and the latter those with simple spines. Wille, in 1890, elevated these to generic rank, but on most inadequate grounds, as may be seen by mere reference to the forms of the common species *X. armatum*. Moreover, in some of the tropical and subtropical species partially divided spines occur of such a nature that it is impossible to refer these species with certainty to either of Wille's proposed genera. It is also significant that in his revised account of the Chlorophyceæ in Engler & Prantl, 'Natürl. Pflanzenfam.' 1909, Wille has himself submerged his proposed genera in the genus *Xanthidium*.

Boldt, in 1888, suggested that the genus should be subdivided into *Euxanthidium*, with parietal chloroplasts, and *Centrenterium*, with axile chloroplasts. For the reasons that the disposition of the chloroplasts of most species of *Xanthidium* is entirely unknown, and that the parietal disposition of chloroplasts may be acquired at any time by any Desmid, and is therefore no criterion of its affinities [*vide* Vol. II, p. 126], these suggestions cannot be accepted. Moreover, the chloroplasts do not appear to be constant and may sometimes be parietal and sometimes axile in the same species.

Turner, in 1893, adopted Lundell's two subdivisions, to which he added a third, *Micracanthum*; and this subdivision of the genus into three sections we have adopted.

The decisive combination of characters which we adopt for this genus is the possession of spines and the presence of a differentiated area in the centre of each side of a compressed semicell. Even in the very rare triangular forms the differentiated area is present in the middle of each of the three sides.

This central area (whether protuberance or thickening) is the only distinction which really separates *Xanthidium* from *Arthrodesmus*.

We arrange the British species as follows :—

Section A. *Schizacanthum* Lund. Cells large or very large, with tri- or quadrifurcate processes.

1. *X. armatum*.

Section B. *Holacanthum* Lund. Cells of medium size or small, with long simple spines.

a. Semicells with one pair of spines on each side.

* Semicells elliptic, lateral spines in a vertical plane, central area small and slightly thickened.

2. *X. subhastiferum*.

** Semicells elliptic-hexagonal (not regularly elliptic), lateral spines not in a vertical plane, central area large, thickened, and scrobiculated.

3. *X. tetracentrotum*.

*** Semicells elliptic-hexagonal, lateral spines in a vertical plane, central area absent or small, sometimes scrobiculated.

4. *X. controversum.*

b. Semicells with two pairs of spines on each side.

* Cells small; semicells trapeziform with retuse (or straight) sides and apex.

5. *X. Smithii.*

** Cells of medium size; semicells more or less elliptic-hexagonal.

6. *X. antilopæum.*

c. Semicells with two pairs of spines and one single spine on each side.

7. *X. cristatum.*

d. Semicells with three pairs of spines on each side.

8. *X. fasciculatum.*

e. Semicells with about 8–10 spines on each side, in pairs or more or less irregularly scattered.

* Spines mostly in pairs.

9. *X. Brébissonii.*

** Spines irregularly scattered.

10. *X. aculeatum.*

Section C. *Micracanthum* Turner. Cells small or very small, with very minute simple spines.

11. *X. variabile.*
12. *X. Robinsonianum.*
13. *X. Orcadense.*
14. *X. apiculiferum.*
15. *X. concinnum.*

1. **Xanthidium armatum** (Bréb.) Rabenh.

(Pl. CIV, figs. 1–5.)

Cosmarium armatum Bréb. in Menegh. Synops. Desm. 1840, p. 218.
Euastrum armatum Kütz. Phyc. germ. 1845, p. 137.
Xanthidium furcatum Ralfs in Ann. Mag. Nat. Hist. xiv, 1845, p. 466, t. 12, f. 1.
Xanthidium armatum (Bréb.) Rabenh. Deutschl. Kryptogamenfl. Bd. II, Algen, Leipsic, 1847, p. 55; Ralfs, Brit. Desm. 1848, p. 112, t. 18; Arch. in Pritch. Infus. 1861, p. 735, t. 1, f. 27–28; Rabenh. Flor. Europ. Algar. III, 1868, p. 222; Lund. Desm. Suec. 1871, p. 75, t. 5, f. 4; Arch. in Q. J. Micr. Sci. xiii, 1873, p. 37; Kirchn. Alg. Schles. 1878, p. 154; Wolle, Desm. U. S. 1884, p. 92, t. 21, f. 2–4 [figures poor]; Cooke, Brit. Desm. 1887, p. 129, t. 45, f. 1 [figures very poor]; Hansg. Prodr. Algenfl. Böhm. 1888, p. 191, f. 114; De Toni, Syll. Alg. 1889, p. 916; West, Alg. N. Wales, 1890, p. 291; Alg. W. Ireland, 1892, p. 164; Alg. Engl. Lake District, 1892, p. 730; Roy & Biss. Scott. Desm. 1893, p. 244; Nordst. Index Desm. 1896, p. 51; W. & G. S. West, Alg. S. England, 1897, p. 484; Schmidle, Lappmark Süsswasseralgen, 1898, p. 21; W. & G. S. West, Alga-fl. Yorks. 1900, p. 67; Börg. Freshw. Alg. Færoës,

1901, p. 229; W. & G. S. West, Alg. N. Ireland, 1902, p. 30; Hirn, Desm. Finland, 1903, p. 23; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 527; Cushm. in Bull. Tor. Bot. Club. 1904, xxxi, p. 583, t. 26, f. 7; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, p. 85; Borge, Beiträge Alg. Schweden, 1906, p. 28; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 180; Phytoplankton Engl. Lake Distr. 1909, p. 138.

Euastrum Bigorrianum Perty in Mittheil. d. naturforsch. Ges. Bern, 1849, p. 174.

Zygoxanthium Bigorrianum Perty, Kleinst. Lebensf. 1852, p. 209, t. 16, f. 23.

Didymidium (Xanthidium) armatum Reinsch, Algenfl. Frank. 1867, p. 129.

Xanthidium Bigorrianum (Perty), Rabenh. Flor. Europ. Alg. III, 1868, p. 222.

X. armatum var. *Wolleanum* Turn. New and Rare Desm. 1885, p. 938, t. 15, f. 18.

X. armatum var. *Americanum* Turn. l. c. t. 15, f. 19.

Schizacanthum armatum (Bréb.) Wille in Engler & Prantl, Natürl. Pflanzenfamil. 1890, p. 11, 12, f. 7E.

Xanthidium armatum var. *supernumerarium* Schmidle, Beitr. alp. Alg. 1895, p. 348, t. 15, f. 8.

Cells large, from $1\frac{1}{3}$ to $1\frac{1}{2}$ times as long as broad, deeply constricted, sinus open and acute-angled, somewhat acuminate at the extremity; semicells somewhat octangular (reckoning the isthmus as one of the eight sides), lower margins slightly convex, inferior and superior lateral margins usually very slightly concave but not infrequently straight, apex straight or slightly convex, with the two lateral angles and the apical angle on each side furnished with short, stout, solid, wart-like spines, which are 2–4 (commonly 3)-furcate at the apex, with a similar stout furcate spine within each lateral angle and with a pair just within the apex (all of which are subject to variation), in the centre of the semicell with a ring of simple or emarginate teeth representing the serrated edge of a large central wart. Side view of semicell ovate-rectangular, near the base on each side with a large truncate toothed wart, apical angles furnished with 2–3-furcate spines, and with 2 similar furcate spines at the truncate apical margin. Vertical view elliptic-oblong with subtruncate poles, with a large truncate toothed wart at the middle on each side, and with four stout 2–3-furcate spines at equal intervals along each polar margin. Cell-wall punctate. Chloroplasts sometimes distinctly parietal,

4 in each semicell, each with several pyrenoids; but frequently variable (?).

Zygospore globose or subglobose, thick-walled, and rather densely covered with large scrobiculations.

Length (with spines) 116–185 μ; breadth (with spines) 78–127 μ; breadth of isthmus 30–43 μ; thickness 63–88 μ; diam. zygosp. 100–131 μ.

England.—Cumberland! Westmoreland! Lancashire! W. and N. Yorks! Norfolk (*Cooke*). Herts (*Hassall*). Bucks! Warwickshire (*Wills*). Surrey! Sussex! Kent! Hants! Devon! (*Bennett*). Cornwall! (*Ralfs*). In the plankton of Codale and Easdale Tarns, Westmoreland!

Wales.—General! Zygospores from Capel Curig, Carnarvonshire (*Roy*). Not uncommon in the plankton.

Scotland.—General! Zygospores from Loch Inver, Sutherland; Cammie, Kincardine; and Glencoe, Argyll (*Roy & Bissett*). Lewis, Harris, N. and S. Uist, and Benbecula, Outer Hebrides! General in the plankton of the western lochs! Zygospores in abundance from bog near Loch Coruisk, Skye!

Ireland.—Donegal! Mayo! Galway! Kerry! Dublin and Wicklow (*Archer*). Down! Very rare in the plankton of the lakes in Galway!

Geogr. Distribution.—France. Germany. Austria and Galicia. Hungary. Italy. Norway. Sweden (with zygospores). Denmark. Finland. Poland. N. and S. Russia. Faeroes. N. India. New Zealand (var.). Cuba. United States.

X. armatum is generally distributed over the whole of the British Islands except the eastern counties of England. It often occurs in abundance in *Sphagnum*-bogs and at the boggy margins of lakes. It also occurs in both the plankton and benthos of the lakes of the western British areas, being associated with various species of *Cosmarium*, *Staurastrum*, *Micrasterias*, and *Euastrum*, and with the filamentous genera *Gymnozyga* and *Hyalotheca*.

One of the handsomest of Desmids, *X. armatum* is the only British species which possesses furcate spines. Six series of

these spines traverse the semicell at right-angles to the plane of compression, each series forming a short arc over one of the six angles of the semicell. The variation in *X. armatum*, which at first sight appears very considerable, is practically confined to the variation in the number, in the degree of subdivision, and in the relative regularity in disposition of these furcate spines. Normally, there are four such stout spines in each series, but this is frequently reduced to three in some of the series. The trifurcate spine also seems to be the typical one, although bifurcate spines are common, and others divided to a greater or lesser extent into four teeth are scarcely less frequent. The large truncated wart in the centre of each semicell is furnished, in the typical form, with a marginal ring of simple or emarginate teeth. The disposition of the furcate spines is not always in *regular* series, and where such a departure from the regular arrangement exists, even in only a few of the series, the front view of the Desmid presents an aspect of irregularity which has been largely responsible for such named varieties as "var. *supernumeraria* Schmidle." "var. *incongruum* Turn.," and "var. *intermedium* Schröder."

The stout spines of this species are very slightly hollowed at the base, but are otherwise solid; and the punctulation of the cell-wall is much more conspicuous in some individuals than in others.

We figure on Plate CV, fig. 5, a curious form of *X. armatum*, which must be either a reduction-form resulting from rapid division or one of the early stages in the development from the zygospore. Only two specimens have been seen, both from the west of Ireland in 1892. Hustedt has recently mentioned ('Desm. et Bacill. aus Tirol,' 1911, p. 337, fig. 27) a similar reduction-form from the Tyrol.

Var. **fissum** Nordst. (Pl. CV, figs. 1, 2.)

X. armatum var. *fissum* Nordst. Alg. aq. dulc. et Char. Sandvic. 1878, p. 17, t. 2, f. 6; Schmidle, Lappmark Süsswasseralgen, 1898, p. 21.

Spines much more elongate, 2–3-furcate at the apex; central wart of the semicells elongate and similar to the marginal spines, 3–4-furcate at the apex.

Length (with spines) 135–160 μ; breadth (with spines) 104–122 μ; breadth of isthmus 30–34 μ; thickness 80–86 μ.

Wales.—Capel Curig lakes, Llyn-y-cwm-ffynon, and Glaslyn, Carnarvonshire!

Geogr. Distribution.—Norway. Sandwich Islands.

This is a very distinct variety, at once recognizable by the elongation of the basal portions of the spines, and by the nature of the central protuberance, which is very similar to the marginal spines. It is apparently a very rare variety, but it occurred in great abundance in Llyn-y-cwm-ffynon, both in the benthos and the plankton.

Var. **irregularius** West. (Pl. CV, figs. 3, 4.)

X. armatum var. *irregularius* West, Alg. W. Ireland, 1892, p. 164, t. 21, f. 1.

Spines of variable character, often of the nature of emarginate or tridentate warts, often simple with obtuse extremities, generally very irregular in disposition.

Length (with spines) 172–181 μ; breadth (with spines) 110–126 μ; breadth of isthmus 41–50 μ.

Ireland.—Ballynahinch and Kylemore, Galway!

Var. **cervicorne** W. & G. S. West. (Pl. CVI, figs. 1–4.)

X. armatum "finely developed form" Wolle, Desm. U. S. 1884, p. 92, t. 21, f. 1.

X. armatum var. *cervicorne* W. & G. S. West, Some Desm. U. S. 1898, p. 300, fig. xylogr. 3 *a–c*; Notes Alg. III, 1903, p. 74; Cushman in Rhodora, vii, 1905, p. 259; W. & G. S. West, Brit. Freshw. Phytoplankton, etc. 1909, p. 180.

Larger than the type, with the spines much longer, basal part of spines elongated as in var. *fissum*, apical part more deeply 3–5-furcate and frequently branched in a subdichotomous manner; teeth of the central wart much larger and more elongated.

Length (with spines) 242–255 μ; breadth (with spines) 170–181 μ; breadth of isthmus 47–51 μ.

Wales.—In the plankton of the Capel Curig lakes and Llynau Dywaunedd, Carnarvonshire!

Scotland.—Rhiconich, and in the plankton of Loch Shin, Sutherland!

Geogr. Distribution.—United States.

This variety is one of the very handsomest of British Desmids. The spines are greatly elongated and much furcate, the branches reminding one of the tynes of an antler.

2. **Xanthidium subhastiferum** West.

(Pl. CVI, figs. 5–9.)

Xanthidium subhastiferum West, Alg. W. Ireland, 1892, p. 166, t. 22, f. 4; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 540, t. 16, f. 4–5; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, pp. 85, 102; Brit. Freshw. Phytoplankton, etc. 1909, p. 180.

X. quadricornutum Roy & Biss. forma *longispina* Börg. Freshw. Alg. Færoës, 1901, p. 229, t. 7, f. 13.

Cells rather under medium size, about as long as broad, deeply constricted, sinus acute-angled, open, sometimes acuminate at the apex; semicells elliptic or oblong-elliptic, often slightly flattened at both base and apex, each lateral margin furnished with two simple divergent spines situated in the same vertical plane; in the centre of the semicell with a small, rounded, thickened area. Side view of semicell circular. Vertical view elliptic, with an elongated spine at each pole, and with a slight thickening, generally faintly protuberant, at the middle on each side.

Zygospore unknown.

Length 43–54 μ; breadth without spines 44–53·5 μ; breadth with spines 64–86 μ; length of spines 12·5–18 μ; breadth of isthmus 13–19 μ; thickness 25–29 μ.

Scotland.—Plankton of Lochs nan Cuinne and Ghriama, Sutherland (*J. Murray*)! Plankton of Loch Luichart, Ross! Plankton of Loch Morar and Loch Shiel, Inverness! Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

Ireland.—In the plankton of the small lakes between Clifden and Roundstone, Galway! Lough Guitane and Glen Caragh, Kerry! Common in the plankton of the lakes of Kerry!

Geogr. Distribution.—Faeroes.

X. subhastiferum is for the most part a plankton-Desmid, occurring now and then in considerable quantity in the western lakes. It sometimes exhibits a certain amount of irregularity in the disposition of the spines, but such irregularities are merely slight monstrosities due to rapidity of division and other causes. The normal specimen possesses two equal divergent spines placed one above the other, but occasionally one spine is reduced or absent (Pl. CVI, fig. 8), or a third incipient spine is developed between the lateral pair.

It is a very distinct species, but should be carefully compared with *X. tetracentrotum* Wolle.

Var. **Murrayi** W. & G. S. West. (Pl. CVI, figs. 10, 11.)

X. subhastiferum var. *Murrayi* W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 540, t. 16, f. 6; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Brit. Freshw. Phytoplankton, etc., 1909, p. 180; Phytoplankton Engl. Lake District, 1909, pp. 138, 288.

Semicells somewhat obsemicircular, with the apex slightly convex but flattened in the middle, and with the two lateral spines of each side disposed in a horizontal (or sometimes more or less oblique) plane.

Length 52–61 μ; breadth without spines 50·5–62 μ, with spines 87–97 μ; breadth of isthmus 17–19 μ.

England.—Plankton of Windermere, Hawes Water, and Grasmere, Westmoreland!

Scotland.—Plankton of Loch Morar, Inverness!; and Loch nan Cuinne, Sutherland (*J. Murray*)!

This variety seems to be confined to the plankton, and since its first discovery in Loch nan Cuinne, Sutherland, it has been found in considerable abundance in other Scottish and English lakes. It is one of the leading constituents of the autumn plankton of Windermere, occurring in quantity from September to November.

A slight abnormality was observed in a single specimen from Grasmere in the English Lake District, one semicell possessing an obliquely disposed pair of short, curved, apical spines (*vide* Pl. CIII, fig. 14).

A triangular form, which we have named "forma triquetra" occurs in the plankton of Loch Lomond (*vide* Pl. CVII, figs. 9, 10). This differs only in the triangular character of the

semicells, being strictly analogous to *X. antilopæum* var. *triquetrum* Lundell, and as in that variety the thickened central area is present in the middle of each of the three sides. It is at its greatest abundance from July to September.

3. **Xanthidium tetracentrotum** Wolle.

(Pl. CVII, figs. 1, 2.)

Xanthidium tetracentrotum Wolle in Bull. Torr. Bot. Club, 1882, p. 29, t. 13, f. 14; Wolle, Desm, U. S. 1884, p. 95, t. 22, f. 8–9; De Toni, Syll. Alg. 1889, p. 923; W. & G. S. West, Some N. Amer. Desm. 1896, p. 253, t. 15, f. 24; Cushman in Rhodora, vii, 1905, p. 260, t. 64, f. 8, 9.
Arthrodesmus incrassatus Lagerh. Bidrag. Amerik. Desm.-fl. 1885, p. 242, t. 27, f. 18; Wolle, Freshw. Alg. U. S. 1887, p. 35, t. 61, f. 6; De Toni, Syll. Alg. 1889, p. 1061.

Cells somewhat small, a little longer than broad, deeply constricted, sinus widely open outwards with a submamillate extremity; semicells subelliptic or reniform-elliptic, with the dorsal margin more convex than the ventral margin, slightly flattened at the middle of the ventral side and with the cell-wall faintly thickened in the middle of the apex, each lateral angle furnished with either one or two simple, elongated, outwardly-curved spines; in the centre of the semicell with a thickened (and usually yellow-brown) area of considerable size, possessing prominent scrobiculations which are variable in size, number, and disposition. Side view of semicell subcircular or obovate-subcircular, with a conspicuous thickening of the wall on each side. Vertical view rhomboid-elliptic, with either one or two simple spines at each pole, and a prominent thickening of the wall in the median part of each side.

Zygospore unknown.

Length 41–50 μ; breadth without spines 33–40 μ, with spines, 54–66 μ; breadth of isthmus 12 μ; thickness 23–25 μ.

Geogr. Distribution.—United States.

The typical form of this species is not known to occur in the British Islands. Its most characteristic feature is the large thickened and scrobiculated area in the centre of the semicell. The single or paired lateral spines are also distinctive.

Forma **protuberans** *nob.* (Pl. CVII, fig. 3.)

A large form with the semicells elliptic-hexagonal, and with a small protuberance in the middle of the scrobiculated central area.

Length 58 μ; breadth without spines 52 μ, with spines 79 μ; breadth of isthmus 15 μ; thickness 36 μ.

Scotland.—In the plankton of Loch Laxadale, Harris, Outer Hebrides!

Var. **quadricornutum** (Roy & Biss.) W. & G. S. West. (Pl. CVII, fig. 4.)

Xanthidium quadricornutum Roy & Biss. Scott. Desm. 1893, p. 245, t. 4, f. 5.

X. tetracentrotum Wolle var. *quadricornutum* (Roy & Biss.) W. & G. S. West, Notes Alg. II, 1900, p. 291.

Spines shorter, with the pairs rather irregularly disposed; central area large, not much thickened and not protuberant, densely scrobiculate.

Length 47·5–50 μ; breadth (without spines) 45–47·5 μ; breadth of isthmus 14–15 μ.

Scotland.—In a pool near Durris Bridge, Kincardine (*Roy & Bissett*).

As we pointed out in the 'Journal of Botany,' in 1900, this variety differs very little from the American plant first described by Wolle.

4. **Xanthidium controversum** W. & G. S. West. (Pl. CVII, figs. 5, 6.)

Xanthidium antilopæum (Bréb.) Kütz. 'forma' W. & G. S. West, Some N. Amer. Desm. 1896, p. 252, t. 16, f. 1.

X. controversum W. & G. S. West, Some Desm. U. S. 1898, p. 298, t. 17, f. 2; Cushman in Rhodora, vii, 1905, p. 260; Nordst. Index Desmid. Suppl. 1908, p. 41.

Cells rather under medium size, $1\frac{1}{5}$ times longer than broad (without spines), deeply constricted, sinus open and acute-angled, with an acuminate apex; semicells elliptic-hexagonal, upper lateral margins sometimes slightly retuse, apex widely truncate, lateral and apical angles furnished with a single spine (or some-

times with a pair of spines), all the spines upwardly curved; central area of semicell not differentiated or very slightly thickened. Side view of semicell circular. Vertical view elliptic. Cell-wall minutely punctate.

Zygospore unknown.

Length without spines 36·5–38 μ, with spines 55–59 μ; breadth without spines 31 μ, with spines 52–56 μ; breadth of isthmus 7·6–8 μ; thickness 20–21 μ.

Geogr. Distribution.—United States.

This is the only species of the genus in which the type form is practically destitute of a differentiated central area. As yet the typical form has not been observed in the British Islands.

In outline the semicells are very similar to those of *X. antilopæum*, but it is a smaller species with the spines of each semicell more upwardly directed, and often with only solitary spines at the angles. It appears to stand in an intermediate position between *X. antilopæum* and *X. inchoatum* Nordst.

Var. **planctonicum** W. & G. S. West. (Pl. CVII, figs. 7, 8.)

X. controversum var. *planctonicum* W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 539, t. 16, f. 2, 3; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 72; Brit. Freshw. Phytoplankton, etc., 1909, p. 180.

A larger variety, with the sinus less open and linear with a dilated extremity; central area of semicells finely scrobiculated and with a small central protuberance. Vertical view with a small tumour at the middle on each side.

Length without spines 49–52 μ; breadth without spines 46–49 μ; length of spines 16–23 μ; breadth of isthmus 12·5–13·5 μ; thickness 31 μ.

Scotland.—Plankton of Loch Shin and Loch a Gharbh Bhaid Mhoir, Sutherland! Plankton of Loch Ghriama, Sutherland (*J. Murray*)! Plankton of Lochs an Sgath, Langabhat, Shrubhail, Stranabhat, and an Tomain, Lewis, Outer Hebrides!

This distinctive variety occurred abundantly in Loch Shin, and we suggested at the time of its description that owing to its striking characters it might perhaps be regarded as a distinct species—*X. planctonicum*.

The cells are larger than those of the type, the sinus is closed, the spines are longer, and those of the inferior angles are less divergent; in the centre of the semicells is a scrobiculated area which is thickened and possesses a small protuberance clearly visible in the vertical and lateral views. As in typical *X. controversum*, single spines are frequently replaced by a pair.

It should be compared with *X. tetracanthum* Turner ('Freshw. Alg. E. India,' 1893, p. 101, t. 13, f. 29), from which it differs in its hexagonal semicells, closed sinus, and longer spines.

5. **Xanthidium Smithii** Arch.

(Pl. CVIII, figs. 1–4; Pl. CXI, fig. 10.)

Xanthidium Smithii Arch. in Proc. Dubl. Nat. Hist. Soc. iii, 1860, p. 51, t. i, f. 10–12; in Q. J. Micr. Sci. 1860, p. 238, t. 11; in Pritch. Infus. 1861, p. 736; Rabenh. Flor. Europ. Alg. III, 1868, p. 224; Cooke, Brit. Desm. 1887, p. 133, t. 45, f. 4; West, Alg. W. Ireland, 1892, p. 166; Roy & Biss. Scott. Desm. 1893, p. 245; W. & G. S. West, Notes Alg. III, 1903, p. 74.

Arthrodesmus octocornis Ehr. var. *major* Roy & Biss. Scott. Desm. 1894, t. 2, f. 20 [not Ralfs].

Cells small, deeply constricted, sinus open and acute-angled with a rounded apex; semicells rectangular-trapeziform, basal and apical angles rounded, sides and apex very slightly concave (or almost straight), each angle furnished with a pair of simple, straight, and fairly long spines, with a small thickened area in the centre of the semicell. Side view of semicell circular, with a small protuberance at the middle on each side, and with a pair of diverging spines at the apex. Vertical view elliptic-rhomboid, with a small rounded protuberance at the middle on each side, and with a pair of diverging spines at each pole. Chloroplasts . . . . . ?

Zygospore globose, furnished with long, simple, acute spines (about 7 visible at the actual margin), each arising from a widely conical base.

Length without spines 21–30 μ; breadth without spines 19–28 μ; length of spines 6·5–8 μ; breadth of isthmus 8–11 μ; thickness 12–16 μ; diam. zygosp. without spines 25–26 μ, with spines 66–68 μ.

England.—Near Bowness, Westmoreland (*Bissett*).

Wales.—Moel Siabod, Carnarvonshire! Rhos Goch Bog, Radnorshire!

Scotland.—Cammie in Strachan, Kincardine; zygospore from near Aboyne, Aberdeen (*Roy & Bissett*). Garynahine, Lewis, and Harris, Outer Hebrides!

Ireland.—Lakes between Clifden and Roundstone, Galway! Cromagloun, and Torc Mountain, Kerry! Castletown, Cork!

Geogr. Distribution.—Patagonia.

X. Smithii is a very rare species which apparently only occurs in abundance in a few districts in North Wales, the west of Ireland, and the Outer Hebrides. It is one of the most distinctive species of the genus and cannot well be confounded with any other.

Var. **majus** (Ralfs) *nob.* (Pl. CVIII, fig. 5.)

Xanthidium ? octocorne (Ehrenb.) Ralfs var. *major* Ralfs, Brit. Desm. 1848, p. 116, t. 20, f. 2 *f–i*.

Arthrodesmus octocornis Ehrenb. var. *major* Cooke, Brit. Desm. 1887, p. 135, t. 47, f. 2 *a, b, c, f, g*; Lund. Desm. Suec. 1871, p. 56; Nordst. Norges. Desm. 1873, p. 25; De Toni, Syll. Alg. 1889, p. 1063; Roy & Biss. Scott. Desm. 1894, p. 41 [but not t. 2, f. 20]; Eichler in Pamiet. Fizyograf. Akad. Umiej. Krakow, xiii, 1895, p. 60.

Slightly larger than the type, sides and apex of semicells rather more concave, spines often shorter and stouter, from one to three inserted at each angle, and often of different lengths; central area of semicell slightly thickened, but not protuberant.

Length without spines 26–36 μ; breadth without spines 27–32 μ; breadth of isthmus 9–12 μ; thickness 12–16 μ; length of spines 4–9·5 μ.

Wales.—Dolgelly, Merioneth (*Ralfs*).

Scotland.—Orkneys, Sutherland!, Ross, Inverness, Aberdeen, Kincardine, Forfar, Perth, and Argyll (*Roy & Bissett*).

IRELAND.—Cromagloun, Kerry!

Geogr. Distribution.—Norway. Sweden. Poland.

This variety is not quite so rare as the type, but is very local and confined to the rich bogs of the old formations. It is easily distinguished by its stouter habit and thicker spines, which are somewhat variable. Two is the usual number at each angle of the semicell, but the basal angles are frequently furnished with three, and more rarely with only one.

It seems to us an error of judgment to place this variety under *Arthrodesmus octocornis* notwithstanding the fact that the semicells are identical in outward form. The spines are *usually in pairs,* and the vertical view shows that the central area of the semicell is very slightly thickened. The association of these characters is clear evidence that this plant should be placed in the genus *Xanthidium.*

There seems little doubt that the Desmid described by Reinsch as *Xanthidium bicornutum* should be relegated to this variety. It might be regarded as:

Forma MINOR [=*Xanthidium bicornutum* Reinsch, Spec. Gen. Alg. 1867, p. 119, t. 20 A III, f. 1–6; *Didymidium* (*Xanthidium*) *bicornutum* Reinsch, Algenfl. Frank. 1867, p. 128, t. 9, f. 7; *Arthrodesmus? bicornutus* De Toni, Syll. Alg. 1889, p. 1064].

Var. **collum** West. (Pl. CVIII, fig. 6.)

X. Smithii var. *collum* West. Alg. W. Ireland, 1892, p. 166, t. 22, f. 5.

Each superior angle of the semicell with three spines; isthmus elongated so that the sinus is wide and rounded-quadrate; central protuberance of semicell rather prominent and a little irregular.

Length without spines 30 μ; breadth without spines 25 μ; breadth of isthmus 9 μ; thickness 15 μ; length of spines 5–7·5 μ.

IRELAND.—Cromagloun, Kerry!

6. **Xanthidium antilopæum** (Bréb.) Kütz. (Pl. CVIII, figs. 7–18.)

? Xanthidium fasciculatum Ehrenb. var. *polygonum* Ehrenb. Infus. 1838, p. 148, t. 10, f. 24*a* [description and figure imperfect].

Heterocarpella antilopæa Bréb. in Cheval. Des. microscop. et de leur usage, Paris, 1839, p. 272.

? Cosmarium antilopæum Bréb. in Menegh. Synops. Desm. 1840, p. 218.

Xanthidium fasciculatum Ehrenb. *a* Ralfs in Ann. Mag. Nat. Hist. xiv, 1845, p. 466, t. 12, f. 3 *a–d*; Brit. Desm. 1848, p. 114, t. 20, f. 1; De Not. Desm. Ital. 1867, t. 4, f. 36; Nordst. Desm. Brasil. 1870, p. 230; Delp. Desm. subalp. 1877, p. 168, t. 13, f. 20–22; Turn. Alg. Strensall Common, 1883, f. 12; Wolle, Desm. U. S. 1884, p. 93, t. 22, f. 4, 5.

X. polygonum Hass. Brit. Freshw. Alg. 1845, p. 360, t. 89, f. 4 [figure poor].

X. antilopæum (Bréb.) Kütz. Spec. Alg. 1849, p. 177; Bréb. Liste Desm. 1856, p. 134; Lund. Desm. Suec. 1871, p. 75; Kirchn. Alg. Schles. 1878, p. 155; Wolle, Desm. U. S. 1884, p. 94, t. 23, f. 1, 2; Cooke, Brit. Desm. 1887, p. 132, t. 46, f. 2; Hansg. Prodr. Algenfl. Böhm. 1888, p. 192; De Toni, Syll. Alg. 1889, p. 920; West, Alg. N. Yorks. 1889, p. 293; Alg. N. Wales, 1890, p 291; Alg. W. Ireland, 1892, p. 165; Alg. Engl. Lake District, 1892, p. 730; Lütkem. Desm. Attersees, 1893, p. 547; Roy & Biss. Scott. Desm. 1893, p. 244; 1894, t. 3, f. 13; W. and G. S. West, New and Int. Freshw. Alg. 1896, p. 156; Alg. S. England, 1897, p. 484; Alga-fl. Yorks. 1900, p. 67; Borg. Freshw. Alg. Færoës. 1901, p. 229; W. & G. S. West, Alg. N. Ireland, 1902, p. 31; Scott. Freshw. Plankton, I. 1903, p. 527; Hirn, Desm. Finland, 1903, p. 23, t. 2, f. 33; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 72; Comp. Study Plankton Irish Lakes, 1906, p. 85; Borge, Beiträge Alg. Schweden, 1906, p. 28; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 182; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 180; Phytoplankton Engl. Lake District, 1909, p. 138.

X. antilopæum var. *hirsutum* Gay, Monogr. loc. Conj. Montpellier, 1884, p. 77; Note Conj. du midi de France, 1884, p. 340.

X. spinulosum Benn. Freshw. Alg. Engl. Lake Distr. 1886, p. 10, t. 2, f. 17 [figure erroneous]; Cooke, Brit. Desm. 1886, p. 132, t. 46, f. 4; De Toni, Syll. Alg. 1889, p. 928.

X. antilopæum var. *ornatum* Anderss. Sverig. Chlor. 1890, p. 13, t. 1, f. 6.

X. fasciculatum var. *ornatum* Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 94, t. 4, f. 6.

X. antilopæum var. *fasciculoides* Lütkem. Desm. Attersees, 1893, p. 547 [=*X. fasciculatum* Ralfs, 1848, t. 20, f. 1*b*; *X. antilopæum* (Bréb.) Kütz. in Wittr. & Nordst. Alg. Exsicc. No. 574.]

X. antilopæum var. *Schmidlei* Borge in Nuova Notarisia, 1895, vi, p. 25.

Cells of medium size, about as long as broad (without spines), deeply constricted, sinus somewhat variable in depth (according to form of basal half of semicell), shortly linear with a slightly dilated extremity; semicells subelliptic-hexagonal, all the angles very slightly rounded, sides and apex usually straight, each of the four exposed angles furnished with a pair of simple, straight or slightly curved, fairly long spines, central area of moderate size, generally round (more rarely elliptic), thickened and variously scrobiculated. Side view of semicell circular or subcircular, with a slight thickening at each side, and a pair of diverging spines on the apical margin. Vertical view elliptic, with a slight thickening (often somewhat protuberant) at the

middle on each side, and with a pair of slightly divergent spines on each polar margin. Cell-wall finely punctate. Chloroplasts generally parietal, four in each semicell, each with one, or more rarely with two, pyrenoids; sometimes irregular, and not infrequently wholly axile.

Zygospore globose, furnished with long, slender spines, slightly widened at the base, and shortly bifurcate at the apex.

Length without spines 42–76 μ, with spines 54–114 μ; breadth without spines 42–72 μ, with spines 57–108 μ; breadth of isthmus 14·5–26 μ; thickness 21–37 μ; diam. zygosp. without spines 45–58 μ, with spines 80–98 μ.

England.—Cumberland! Westmoreland! (*Ralfs*). Lancashire! (*Ralfs*). W. and N. Yorks! Cheshire (*Ralfs*). Essex! Buckinghamshire! Surrey (with zygospores from Thursley Common)! Sussex (*Ralfs*). Hants! (*Ralfs*). Wilts! Devon! Cornwall! (*Ralfs*). Plankton of Buttermere, Ennerdale Water, Brothers' Water, Hayes Water, Hawes Water, Grasmere, Easdale Tarn, and Stickle Tarn, in the English Lake District!

Wales.—Fairly general! Plankton of many Welsh lakes!

Scotland.—Common! Zygospores from Loch Inver, Sutherland, and Logie Coldstone, Aberdeen (*Roy and Bissett*). Common in the plankton.

Ireland.—Donegal! Galway (zygospores from Ballynahinch)! Kerry! Dublin and Wicklow (*Archer*). Armagh! Down! Plankton of the lakes of Galway and Kerry. Lough Neagh!

Geogr. Distribution.—France. Germany. Austria and Galicia. Roumania. Norway (and Finmark). Sweden. Bornholm. Finland. N. Russia. Faeroes. Siberia. Mongolia. Japan. N. India. Central Africa (var.). United States. W. Indies (var.). Brazil. Paraguay.

Xanthidium antilopæum is the most frequent British species of the genus. It rarely occurs in bogs, having a decided pre-

ference for the boggy margins of large pools and lakes, and both the typical form and several varieties are regular constituents of the lake-plankton.

The hexagonal semicells with four pairs of spines are so characteristic that this species in its typical form is not easily confounded with any other. The scrobiculations of the central area are exceedingly variable as can be seen by a scrutiny of figs. 7, 8, 10–18, on Pl. CVIII.

Within certain limits the shape of the semicells is variable, causing a corresponding variation in the length of the sinus (compare figs. 7 and 8 on Pl. CVIII). The spines are somewhat variable both in length and acuteness, and they may be straight or slightly curved, or even somewhat recurved.

The form with the straight and less acute spines has been named "var. *fasciculoides*" by Lütkemüller, but we hesitate to separate this form as a distinct variety as the spines are so variable in length and relative curvature, and the zygospores of the straight-spined and curved-spined forms are exactly alike.

Börgesen, and also Larsen, have questioned the distinction between *X. antilopæum* and *X. fasciculatum*, but judging from the remarks made by Larsen in his 'Freshw. Alg. E. Greenland,' 1904, p. 101, that author does not realize the characters of *X. fasciculatum*. The form he figures is one of the deformed specimens of *X. antilopæum* which are not uncommon in cold northern latitudes and in the plankton of cold lakes.

We have recognized six distinct varieties of *X. antilopæum* in the British Islands, but the two characteristic American varieties, var. *minneapoliense* Wolle and var. *canadense* Joshua, in which a large spine occurs on, or in relation to, the central protuberance, are not known to occur in Britain.

X. antilopæum var. *incertum* Schmidle ('Alg. aus Nyassa-See,' 1903, p. 71, t. 2, f. 5) is not correctly placed under *X. antilopæum*, and should be relegated elsewhere.

Var. **triquetrum** Lund. (Pl. CIX, fig. 1.)

X. antilopæum var. *triquetrum* Lund. Desm. Suec. 1871, p. 76, t. 5, f. 1; Wolle, Desm. U. S. 1884, p. 94, t. 22, f. 1–3 [figures poor]; De Toni, Syll. Alg. 1889, p. 921; Borge, Chlor. Norska Finmark. 1892, p. 8; W. & G. S. West, Phytoplankton Engl. Lake District, 1909, p. 138.

X. antilopæum var. *fasciculoides* Lütkem. forma *triquetra* Lütkem. Desm. Attersees, 1893, p. 547.

A large variety; vertical view triangular, with

straight or very faintly convex sides, each of which is slightly thickened in the middle, angles wide and emarginate, furnished with a pair of stout spines, and within each angle with a similar pair of stout spines. Each semicell with 6 parietal chloroplasts.

Length without spines 81–90 μ, with spines 116–126 μ; breadth without spines 65–82 μ, with spines 97–125 μ; breadth of isthmus 26–28·5 μ.

England.—Plankton of Brothers' Water, Grasmere, and Easdale Tarn in the English Lake District!

Geogr. Distribution.—Sweden. Finmark in Norway. Austria and Galicia. Brazil (forma).

In the British Islands we have only observed this variety in the plankton. Lütkemüller has recorded smaller forms from Austria; length without spines 71 μ, with spines 90 μ; breadth without spines 55 μ, with spines 84 μ.

Var. **polymazum** Nordst. (Pl. CVIII, fig. 19.)

X. antilopæum var. *polymazum* Nordst. Norges Desm. 1873, p. 38, t. 1, f. 19; Wolle, Desm. U. S. 1884, p. 94, t. 23, f. 3, 4 [figures poor]; Börg. Bornholm Desm.-fl. 1889, p. 149; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Cushman in Rhodora, vii, 1905, p. 259; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 180.

Each semicell with a semicircular series of large rounded granules above the central protuberance.

Length without spines 46–68 μ, with spines 62–85 μ; breadth without spines 45–62 μ, with spines 58–76·5 μ; breadth of isthmus 12–16 μ; thickness 28–33 μ.

Scotland.—Plankton of Loch Ghriar, Sutherland; Loch Fadaghoda, Lewis; and Loch nan Eun, N. Uist, Outer Hebrides!

Geogr. Distribution.—Norway. Bornholm. United States.

This is a rare variety in the British Islands and one that we have found only in the plankton. In the original figure given by Nordstedt there is an incipient third spine between the pair at each lateral angle of the semicells, and we often find this spine fully developed so that there are three equal spines at each lateral angle (consult Pl. CIX, fig. 2).

Turner has described a 'forma *major*' of this variety from northern India.

Var. **læve** Schmidle. (Pl. CIX, fig. 3.)

X. antilopæum var. *læve* Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 94, t. 4, f. 7; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Brit. Freshw. Phytoplankton, etc., 1909, p. 180.

A rather large variety in which the semicells are entirely destitute of a thickened or scrobiculated central area. Cell-wall sometimes perfectly smooth, at other times finely punctate.

Length without spines 79–90 μ, with spines 96–121 μ; breadth without spines 62–79 μ, with spines 88–116 μ; breadth of isthmus 20–35 μ.

Scotland.—Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

Ireland.—Bog W. of Lough Neagh, Londonderry!

Geogr. Distribution.—Germany.

A form of this variety with a more or less irregular disposition of the spines was abundant in Derrycrow Bog, near Lurgan, in the north-east of Ireland. This we have named 'forma irregularis' (W. & G. S. West, 'New Brit. Freshw. Alg.' 1894, p. 8, t. 2, f. 44); length without spines 80–82 μ, with spines 105–115 μ; breadth without spines 62–63 μ, with spines 85–100 μ; breadth of isthmus 21–25 μ. (Pl. CIX, fig. 4.)

The form described by Lütkemüller ('Desm. Attersees,' 1893, p. 548) as "var. *fasciculoides* forma *inevolutum*" is probably one of the forms of this variety.

Var. **oligacanthum** Schmidle. (Pl. CIX, fig. 5.)

X. antilopæum var. *oligacanthum* Schmidle, Chlorophy.-Fl. Torfstiche Virnheim, 1894, p. 50, t. 7, f. 10.

Semicells more elliptical than in the type, with only one spine at each of the upper angles, and with no differentiated central area.

Length without spines 46–50 μ; breadth without spines 46–58 μ.

Geogr. Distribution.—Germany.

From Lough Anna and near Lough Magrath in Donegal, Ireland, a form of *X. antilopæum* was observed which we have referred to this variety as "forma spinis longioribus; tumore centrali prominenti et supra tumorem cum scrobiculis numerosis" (*vide* W. & G. S. West, 'Alg. N. Ireland,' 1902, p. 31). Length without spines 39 μ, with spines 54 μ; breadth without spines 41 μ, with spines 65 μ; breadth of isthmus 12·5 μ; thickness 25 μ. (Pl. CIX, fig. 6.)

Var. **hebridarum** W. & G. S. West. (Pl. CIX, fig. 7; Pl. CX, figs. 1, 2.)

X. antilopæum var. *hebridarum* W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 500, t. 7, f. 21; Comp. Study Plankton Irish Lakes, 1906, p. 85; British Freshw. Phytoplankton, etc., 1909, p. 180.

Semicells with three spines on each lateral margin, all of which are disposed in a median vertical plane, one spine only inserted at the upper angles, the other two approximated near the lateral angles; central area consisting of a small obtusely mamillate protuberance around which is grouped in various ways a number of minute scrobiculations.

Length without spines 46–50 μ, with spines 61–71 μ; breadth without spines 42–49 μ, with spines 69–82 μ; breadth of isthmus 12–14 μ; thickness 31 μ.

Scotland.—Plankton of two lochs in Inverness, two in Ross, three in Sutherland, six in Lewis, Outer Hebrides, and three in Harris, Outer Hebrides!

Ireland.—Plankton of several small lakes between Clifden and Roundstone, Galway!

Instead of the normal pair of spines at each upper angle of the semicells, there is in this variety only a single spine, and the pair of spines which should be attached side by side at the lateral angles are here separated some distance apart, and placed more or less vertically over each other. The semicells are therefore not so angular as in typical *X. antilopæum*. The length of the spines is variable, and examples are sometimes met with in which the spines are to some extent reduced and not strictly disposed in one vertical plane. (*vide* Pl. CIX, fig. 7.)

Var. **depauperatum** W. & G. S. West. (Pl. CX, figs. 3–7.)

X. antilopæum forma W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 539, t. 16, f. 1.

X. antilopæum var. *depauperatum* W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 23, t. 1, f. 15, 16; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, p. 85; Brit. Freshw. Phytoplankton, etc., 1909, p. 180; Phytoplankton Engl. Lake District, 1909, p. 138.

Semicells slightly inflated, with the lateral angles very obtuse and generally very slightly truncate; spines 1–3 (more rarely 4) on each lateral margin, very short, of unequal length, and irregularly disposed; central area of normal size and closely scrobiculated, or with only one ring of scrobiculations.

Length without spines 46–55·5 μ; breadth without spines 43–50 μ; length of spines 2–10·5 μ; breadth of isthmus 9·5–14 μ.

England.—Plankton of Buttermere, Crummock Water, and Ennerdale Water, Cumberland!; and of Red Tarn, Grasmere, and Easdale Tarn, Westmoreland!

Wales.—Plankton of several Welsh lakes!

Scotland.—Plankton of Lochs Griama and nan Cuinne, Sutherland; of Loch na Cloiche Sgoilt, Inverness; and of Loch Tay, Perth! Plankton of lakes in Orkneys and Shetlands!

Ireland.—Plankton of lakes of Galway and Kerry!

In this variety the semicells are less hexagonal and more inflated than in the typical form. The spines are fewer, thinner, of unequal length, and show much irregularity in their disposition. In fact, the number and disposition of the spines is generally quite different on the two semicells of the same individual. It is sometimes a distinctive feature of the lake-plankton.

7. **Xanthidium cristatum** Bréb.

(Pl. CX, figs. 8, 9; Pl. CXI, fig. 1.)

Xanthidium cristatum Bréb. in Ralfs' Brit. Desm. 1848, p. 115, t. 19, f. 3 *a–c*; Arch. in Pritch. Infus. 1861, p. 736, t. 2, f. 18, 23; Rabenh. Flor. Europ. Algar. III, 1868, p. 224; Lund. Desm. Suec. 1871, p. 76; Reinsch, Contrib. Alg. et Fung. 1875, p. 92, t. 16, f. 13; Kirchn. Alg.

Schles. 1878, p. 155; Wolle, Desm. U. S. 1884, p. 93, t. 21, f. 6, and 7?; Cooke, Brit. Desm. 1887, p. 133, t. 46, f. 3; Boldt, Desmid. Grönland, 1888, p. 31; De Toni, Syll. Alg. 1889, p. 923; Heimerl, Desm. alp. 1891, p. 595; Hansg. Prodr. Algenfl. Böhm. 1892, p. 252; West, Alg. W. Ireland, 1892, p. 165; Alg. Engl. Lake Distr. 1892, p. 730; Roy & Biss. Scott. Desm 1893, p. 244; Nordst. Index Desmid. 1896, p. 89; W. & G. S. West, Alg. S. England, 1897, p. 484; Alga-fl. Yorks. 1900, p. 67; Scott. Freshw. Plankton, I. 1903, p. 527; Larsen, Freshw. Alg. E. Greenland, 1904, p. 101; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, p. 85; Borge, Beiträge Alg. Schweden, 1905, p. 28; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 354; W. & G. S. West, Brit. Freshw. Phytoplankton, etc. 1909, p. 180.

Didymidium (*Xanthidium*) *cristatum* (Bréb.) Reinsch, Algenfl. Frank. 1867, p. 127.

Xanthidium cristatum var. *reniforme* Cooke, Brit. Desm. 1887, 133.

Holocanthum cristatum (Bréb.) Wille in Engler & Prantl, Natürl. Pflanzenfam. 1890, pp. 11, 12 (c. fig. 7 D).

Cells of medium size, a little longer than broad (without spines), deeply constricted, sinus rather variable, sometimes narrowly linear with a dilated extremity and sometimes slightly open; semicells trapeziform-subsemicircular, with a broad, subreniform, flat, or somewhat convex base, and with a basal, lateral and apical angle on each side, apex truncate and generally straight, basal angles furnished with a single slightly convergent spine, lateral and apical angles each furnished with a pair of divergent spines, spines all simple and straight, central area differentiated into a small thickened protuberance, generally with a slight vertical elongation. Side view of semicell circular, with a more or less flattened protuberance at the middle on each side, and with a pair of divergent spines at the apical margin. Vertical view elliptic, with a small protuberance at the middle on each side, and three slightly divergent spines at each pole. Cell-wall delicately punctate.

Zygospore globose, furnished with numerous, elongated, stout spines which are very slightly emarginate at the apex.

Length without spines 44–55 μ, with spines 60–77 μ; breadth without spines 34·5–48 μ, with spines 48–68 μ; breadth of isthmus 13–15·5 μ; thickness 25–32·5 μ; diam. zygosp. without spines 48·5–51 μ, length of spines 15–16 μ.

England.—Westmoreland! (*Ralfs*). Hawkshead, Lancashire! N. and E. Yorks! Warwickshire (*Wills*). Sussex (*Ralfs*). Hants! Cornwall! (*Ralfs*).

Wales.—Capel Curig! (*Cooke & Wills*) and Moel Siabod, Carnarvonshire!

Scotland.—Sutherland!, Ross, Inverness!, Aberdeen, Kincardine, Forfar, Perth! (*Roy & Bissett*). Plankton of Lochs Fadaghoda, an Sgath, Langabhat, and an Tomain, Lewis, Outer Hebrides; and of Loch nan Eun, N. Uist, Outer Hebrides!

Ireland.—Mayo! Galway! Kerry! Dublin and Wicklow (*Archer*). Plankton of small lakes in Galway!

Geogr. Distribution.—France. Germany. Austria (var.) and Galicia. Hungary. Norway. Sweden. Denmark. Finland. Poland. S. Russia. Greenland. N. India. E. Africa (var.). United States. Brazil.

The distinguishing feature of *X. cristatum* is the solitary spine, in a median plane, at each basal angle of the semicell. The central area is also small, protuberant, and in most type specimens is devoid of either scrobiculations or granules. It is a much less frequent species than *X. antilopæum*, and never occurs in such abundance.

Forma **angulata** West. (Pl. CX, fig. 10.)

X. cristatum forma *angulatum* West, Alg. W. Ireland, 1892, p. 165, t. 22, f. 3.

Semicells more angular; cell-wall distinctly punctate. Length without spines 51 μ, with spines 67 μ; breadth without spines 40–43 μ, with spines 62 μ; breadth of isthmus 12·5 μ; thickness 22·5 μ.

Ireland.—Lough Aunierin, Galway.

Var. **leiodermum** (Roy & Biss.) Turner. (Pl. CX, fig. 11.)

Xanthidium leiodermum Roy & Biss. Japan. Desm. 1886, p. 240, t. 268, f. 11.

X. cristatum var. *glabrum* Lagerh. Bidr. Amerik. Desm.-fl. p. 245.

X. glabrum Lagerh. Krit. Bemerk. Desm. 1887, p. 539; De Toni, Syll. Alg. 1889, p. 930.

X. cristatum var. *leiodermum* (Roy & Biss.) Turn. Freshw. Alg. E. India, 1893, p. 99, t. 12, f. 33.

Central area not protuberant, slightly thickened and sometimes of a yellow colour; cell-wall smooth.

Length without spines 48–54 μ, with spines 65–74 μ; breadth without spines 36–39 μ, with spines 53–55 μ; breadth of isthmus 11–13 μ; thickness 25–30 μ.

England.—Bowness, Westmoreland!

Geogr. Distribution.—India. Japan. United States.

Var. **spinuliferum** West. (Pl. CX, fig. 12.)

X. cristatum var. *spinuliferum* West, Alg. N. Wales, 1890, p. 291, t. 5, f. 21.

Semicells furnished with 4 or 5 additional spines irregularly placed just within the margin.

Length without spines 45 μ, with spines 58 μ; breadth without spines 36 μ, with spines 48 μ.

Wales.—Capel Curig, Carnarvonshire!

Ireland.—Lough Aunierin, Galway!

Var. **uncinatum** Bréb. (Pl. CXI, figs. 2–4.)

? *Xanthidium bisenarium* Ehrenb. in Physik. Abh. Preuss. Ak. d. wiss. zu Berlin, 1841 [1843], pp. 334, 339, 390, 426 [= *Euastrum* No. 11 Bailey in Amer. Journ. of Science and Arts, iv, 1841, p. 296, t. 3, f. 13]; Rabenh. Flor. Europ. Alg. III, 1868, p. 224.

X. cristatum var. *uncinatum* Bréb. in Ralfs' Brit. Desm. 1848, p. 115, t. 19, f. 3 *d–f*; Wille, Sydamerik. Algfl. 1884, p. 18; Cooke, Brit. Desm. 1887, p. 133; De Toni, Syll. Alg. 1889, p. 923; Borg. Desm. Brasil. 1890, p. 44; West, Alg. W. Ireland, 1892, p. 165; Alg. Engl. Lake Distr. 1892, p. 730; Roy & Biss. Scott. Desm. 1893, p. 244; W. & G. S. West, Some N. Amer. Desm. 1896, p. 253, fig. xylogr. 3; Hirn, Desm. Finland, 1903, p. 23, t. 2, f. 34; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 180; Phytoplankton Engl. Lake Distr. 1909, p. 138.

X. bisenarium [forma *typica*] Turner, Freshw. Alg. E. India, 1893, p. 99, t. 12, f. 30; W. & G. S. West, Alg. N. Ireland, 1902, p. 30.

Cells larger and proportionately a little longer; semicells widely subpyramidate with truncate apices, with the 4 pairs of spines directed more vertically upwards; all the spines (single and paired) curved or slightly recurved, often dilated at the base; central area slightly protuberant and furnished with a ring of 8–12 granules surrounding 3–5 central ones, more rarely with a much more irregular granulation.

Length without spines 55–74 μ, with spines 73–91 μ;

breadth without spines 40–64 μ, with spines 55–83 breadth of isthmus 12–20 μ; thickness 31–36 μ.

England.—Near Bowness, Westmoreland! (*Bissett*). Hawkshead and Hampsfell, Lancashire! In the plankton of Derwent Water, Cumberland!

Scotland.—Common (*Roy & Bissett*). Sutherland!

Ireland.—Ballynahinch, Galway! Lough Gartan, Donegal!

Geogr. Distribution.—France. Germany. Norway. Sweden. Central China. N. India. United States.

This distinctive variety is larger than typical *X. cristatum*, with more pyramidate semicells and a granulate central protuberance. The spines are invariably curved, and often recurved, and all the paired spines are turned in a direction more nearly parallel with the longitudinal axis.

The granulation of the central area is variable, and sometimes of a very irregular character. We have previously figured some of these variations as observed in American specimens (*vide* W. & G. S. West, 'Some N. Amer. Desm.' 1896, fig. 3 on p. 253). Messrs. Roy and Bissett mention a curious form from Loch Ruthven, Inverness, "in which the central circlet of granules is replaced by a short, stout, blunt spine."

In many specimens the basal part of the spines is distinctly dilated, and in some this character is so far extended that each of the paired spines is inserted upon a mamillate protuberance of the cell. This form, which we have observed from the United States, we have named "var. *uncinatum* forma *mucronata*" (West, 'Freshw. Alg. Maine II,' 1891, p. 355, t. 315, f. 11).

Var. **Delpontii** Roy & Biss. (Pl. CXI, fig. 5.)

X. cristatum as described and figured by Delponte, Desm. subalp. 1877, p. 75, t. 14, f. 1–11.

X. cristatum var. *Delpontei* Roy & Biss. Scott. Desm. 1893, p. 244.

Cells proportionately wider than in var. *uncinatum*; semicells subsemicircular with stout spines; central area large and furnished with large granules, one in the centre surrounded by an inner circle of 6 or 7 and an outer circle of 10–12.

Length without spines 54–61 μ, with spines 86–95 μ;

breadth without spines 53–56 μ, with spines 76–88 μ; breadth of isthmus 13–16 μ; thickness 35–39 μ.

Scotland.—Scolty, Kincardine (*Roy & Bissett*).

Geogr. Distribution.—Italy.

8. **Xanthidium fasciculatum** Ehrenb.

(Pl. CXI, figs. 6–8.)

Xanthidium fasciculatum Ehrenb. Infus. 1838, p. 147, t. 10, f. 24 b [figure bad]; Arch. in Pritch. Infus. 1861, p. 736 [in part]; Arch. in Q. J. Micr. Sci. vi, 1866, p. 273; Rabenh. Flor. Europ. Alg. III, 1868 p. 223; Lund. Desm. Suec. 1871, p. 75; Lagerh. Bidr. till Amerik. Desm.-fl. 1886, p. 245; Cooke, Brit. Desm. 1887, p. 131, t. 46, f. 1; Hansg. Prodr. Algenfl. Böhm. 1888, p. 192; De Toni, Syll. Alg. 1889, p. 918; Heimerl, Desm. alp. 1891, p. 595; West, Alg. W. Ireland, 1892, p. 165; Turn. Freshw. Alg. E. India, 1893, p. 100, t. 12, f. 34 [figure defective]; Roy & Biss. Scott. Desm. 1893, p. 245; Nordst. Index Desmid. 1896, p. 122; W. & G. S. West, Alg. S. England, 1897, p. 484; Alga-fl. Yorks. 1900, p. 68; ? Börg. Freshw. Alg. Færoës, 1901, p. 229; W. & G. S. West, Alg. N. Ireland, 1902, p. 30; Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Borge, Beiträge Alg. Schweden, 1906, p. 28; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 180.

X. fasciculatum var. *polygonum* Ralfs in Ann. Mag. Nat. Hist. 1845, p. 466, t. 12, f. 3*e*; Brit. Desm. 1848, p. 114, t. 19, f. 4.

Euastrum fasciculatum Kütz. Phyc. german. 1845, p. 137.

Didymidium (*Xanthidium*) *fasciculatum* Reinsch, Algenfl. Frank. 1867, p. 126.

X. fasciculatum var. *ornatum* Nordst. Desmid. Grönland, 1885, p. 12, t. 7, f. 10; Hirn, Desm. Finland, 1903, p. 23; Borge, Beiträge Alg. Schweden, 1906, p. 28.

Holacanthum fasciculatum Franzé in Oesterr. botan. Zeitschr. 1893, p. 384.

Cells of medium size, about as long as broad (without the spines), deeply constricted, sinus linear, sometimes with a dilated extremity; semicells angular-reniform, margin with six equidistant pairs of simple and often rather short spines, apex subtruncate, central area rather small and slightly protuberant, with a ring of 7–10 granules around a central group of 2 or 3 (rarely smooth ?). Side view of semicell subcircular, with a slight protuberance at the middle on each side, and a pair of divergent spines at the apical margin. Vertical view elliptic, with a slight protuberance at the middle on each side, and a pair of divergent spines at each pole.

Zygospore globose, furnished with long, attenuated spines which are bifid at the apex.

Length without spines 44–66 μ, with spines 65–74 μ; breadth without spines 44–59 μ, with spines 62–72 μ; breadth of isthmus 12–21 μ; thickness 31–40 μ.

England.—Westmoreland (*Bissett*). Strensall and Pilmoor, N. Yorks! Austwick Moss, W. Yorks! Surrey! Cornwall! (*Ralfs*).

Wales.—Capel Curig, Carnarvonshire! (*Cooke & Wills*). Dolgelly, Merionethshire (*Ralfs*).

Scotland.—Sutherland!, Ross, Aberdeen, Kincardine, Forfar, Perth, Argyll, Fife (*Roy & Bissett*). Plankton of Loch Cuthaig, Lewis, Outer Hebrides! Hoy, Orkneys!

Ireland.—Lough Anna, Donegal! Derryclare Lough, Ballynahinch, and lakes near Recess, Galway! Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Austria (var.) and Galicia. Hungary. Italy. Norway. Sweden. Denmark. Finland. Poland. N. and S. Russia. Greenland. N. India. W. and E. Africa (var.). United States. Brazil.

Xanthidium fasciculatum and *X. antilopæum* have in the past been greatly confused, although the reasons for such confusion are not altogether obvious. The spines of *X. antilopæum* are somewhat variable, it is true, but no matter what their number or disposition may be, no form of this species has the angularly reniform semicells of *X. fasciculatum*, neither does it possess six equidistant pairs of equal spines.

The central area is always slightly protuberant, and we have invariably found it to possess granules, generally in the form of a small ring surrounding two or three central ones. It was upon this character that Nordstedt in 1885 based his 'var. *ornatum*,' Ralfs having stated that his *X. fasciculatum* var. β *polygonum* [which is *X. fasciculatum* Ehrenb. type] was very near in the shape of its central projections to *X. fasciculatum* Ralfs var. α [which is *X. antilopæum* (Bréb.) Kütz. type]. We consider both Ehrenberg's and Ralfs' account of *X. fasciculatum* to be confused and imperfect, and therefore to a large extent unreliable. All the British, American, and African specimens of *X. fasciculatum* we have examined have possessed a granulated central area, and we conclude therefore

that Nordstedt's var. *ornatum* (from Finland, Sweden, and Greenland) is nothing more than a normally developed form.

The confusion between this species and *X. antilopæum* is not confined to the writings of older authors, but is equally manifest in the publications of many modern investigators. [*vide* remarks by Börgesen, Larsen, etc.]

An American variety—var. *Oronense* W. & G. S. West—from Orono, Maine, which we figure (Pl. CXI, fig. 9) for comparison with the typical form, also possesses a granulated central area and the six equidistant pairs of spines on each semicell.

In the British Islands *X. fasciculatum* is a very much rarer Desmid than *X. antilopæum*.

9. **Xanthidium Brébissonii** Ralfs.

(Pl. CXII, figs. 1 and 3.)

Binatella aculeata Bréb. Alg. Falaise, 1835, p. 58, t. 8.

Xanthidium Brébissonii Ralfs, Brit. Desm. 1848, p. 113, t. 19, f. 2 *a*, *d*; Arch. in Pritch. Infus. 1861, p. 736; Rabenh. Flor. Europ. Alg. III, 1868, p. 223; Cooke, Brit. Desm. 1887, p. 130; De Toni, Syll. Alg. 1889, p. 926; West, Alg. N. Wales, 1890, p. 291; Alg. Engl. Lake District, 1892, p. 730; Roy. & Biss. Scott. Desm. 1893, p. 244; Nordst. Index Desm. 1896, p. 69; W. & G. S. West, Alga-fl. Yorks. 1900, p. 68; Borge Beiträge Alg. Schweden, 1906, p. 28.

Holacanthum Brébissonii Migula, Kryptogamenfl. in Flora Deutschl., Österreich u. Schweiz, Bd. 5, 1906, p. 516, t. 28, f. 6.

Cells of medium size, about as long as broad (without spines), deeply constricted, sinus almost closed at the apex but opening outwards; semicells subsemicircular, base slightly convex and apex a little flattened in the middle, furnished with 8 or 10 pairs of stout marginal spines, central area strongly protuberant and truncate, furnished with a circle of 12–13 prominent granules. Side view of semicell subcircular, with a truncate granulated protuberance at the middle on each side, and 2 or 3 spines at the apical margin. Vertical view elliptic, with 2 or 3 spines at each pole, and a truncate granulated protuberance at the middle on each side.

Zygospores unknown.

Length without spines 61–80 μ, with spines 79–101 μ; breadth without spines 62–76 μ, with spines 80–104 μ; breadth of isthmus 18–27 μ; thickness 36–50 μ.

England.—Brothers' Water and Deepdale, Westmoreland! Bog two miles S. of Clapham, W. Yorks! Strensall, N. Yorks (*Turner*). Gloucester (*Ralfs*). Piltdown Common, Sussex (*Jenner*). Penzance (*Ralfs*) and near St. Just!, Cornwall.

Wales.—Llyn Padarn!, and Capel Curig! (*Cooke & Wills*), Carnarvonshire.

Scotland.—Aberdeen, Kincardine, Forfar, Perth!, Dumbarton. (*Roy & Bissett*). Renfrew!

Ireland.—Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Italy. Norway. Sweden. Bornholm.

X. Brebissonii is an uncommon species which is very local in its distribution. The form of its semicells and the number of its paired spines are its distinguishing features. The spines exhibit considerable variability in disposition, and the spines of any pair may be inserted close together or far apart.

Var. **varians** Ralfs. (Pl. CXII, figs. 2 and 4.)

X. Brébissonii var. *varians* Ralfs, Brit. Desm. 1848, p. 113, t. 19, f. 2 *b*, *c*, *d* West, Alg. Engl. Lake Distr. 1892, p. 730.

Semicells proportionately wider, on each side with a small basal protuberance projecting into the sinus; spines generally more curved (often uncinate).

Length without spines 61 μ, with spines 82 μ; breadth without spines 76 μ, with spines 108 μ; breadth of isthmus 14–20 μ; thickness 46 μ.

England.— Deepdale, Westmoreland! Piltdown Common, Sussex (*Jenner*). Trewellard near Penzance, Cornwall (*Ralfs*).

10. **Xanthidium aculeatum** Ehrenb.

(Pl. CXII, figs. 5–9.)

Xanthidium aculeatum Ehrenb. in Abh. Acad. Wiss. Berlin, 1833, p. 318 [in part]; l. c. 1836, t. 1, f. 11; Infus. 1838, p. 147, t. 10, f. xxiii *b* [figure bad]; Ralfs in Ann. Mag. Nat. Hist. 1845, p. 467, t. 12, f. 2; Hass. Brit. Freshw. Alg. 1845, p. 360, t. 89, f. 3 [figure bad]; Ralfs, Brit. Desm. 1848, p. 113, t. 19, f. 1; Arch. in Pritch. Infus. 1861, p. 736; Rabenh. Flor. Europ. Alg. III, 1868, p. 222; Lund. Desm. Suec. 1871, p. 75, t. 5, f. 5; Kirchn. Alg. Schles. 1878, p. 155; Wolle, Desm. U. S. 1884, p. 92, t. 23, f. 10–12 [figures bad]; Cooke, Brit. Desm. 1887, p. 130,

t. 45, f. 2; t. 43, f. 10; Hansg. Prodr. Algenfl. Böhm. 1888, p. 191; De Toni, Syll. Alg. 1889, p. 918; West, Alg. N. Yorks. 1889, p. 293; Alg. N. Wales, 1890, p. 291; Alg. W. Ireland, 1892, p. 164; Alg. Engl. Lake Distr. 1892, p. 730; Roy & Biss. Scott. Desm. 1893, p. 244; Nordst. Index Desm. 1896, p. 39; W. & G. S. West, Alga-fl. Yorks. 1900, p. 68; Börg. Freshw. Alg. Færoës, 1901, p. 229; W. & G. S. West, Alg. N. Ireland, 1902, p. 31; Borge, Beiträge Alg. Schweden, 1906, p. 28.

Heterocarpella aculeata Bréb. in Cheval, microscop. et usage, 1839, p. 272.

Zygoxanthium aculeatum Kütz. Spec. Alg. 1849, p. 178.

Didymidium (*Xanthidium*) *aculeatum* Reinsch, Algenfl. Frank. 1867, p. 129.

Holacanthum aculeatum Wille in Engler & Prantl, Natürl. Pflanzenfam. 1890, p. 11.

Cells of medium size, about as long as broad (without spines), deeply constricted, sinus almost closed at the apex but gradually opening outwards; semicells elliptic-reniform or elliptic-subsemicircular, apex subtruncate and often slightly elevated, basal angles sometimes broadly rounded, sometimes rounded-subrectangular; spines stout, irregular in disposition, not arranged in definite pairs, disposed at or near the margin (in a broad irregular band along the greatest circumference); central area a prominent truncate protuberance, sometimes granulated round the margin but often emarginate and rather irregularly lobed, frequently with an emarginate wart or a spine, or both, immediately above the central protuberance. Side view of semicell subcircular, with a prominent truncate protuberance at each side, often with a smaller emarginate wart immediately above it, and with 4–5 spines visible at the apical margin. Vertical view elliptic, with a truncate, granulate or emarginate protuberance at the middle on each side, and with 7 or 8 spines showing round each polar margin. Cell-wall punctate or finely scrobiculate.

Zygospore globose, furnished with numerous long, sharply-pointed spines, each arising from a dilated base.

Length without spines 64–76 μ, with spines 75–90 μ; breadth without spines 62–77 μ, with spines 79–96 μ; breadth of isthmus 19–22·5 μ; thickness 35–45 μ; diam. zygosp. without spines 66–70 μ, with spines 126–136 μ.

England.—Cumberland! Westmoreland! (*Bissett*). Lancashire! W., N., and E. Yorks! Gloucester, Sussex, Kent, Hants, and Cornwall! (*Ralfs*).

Wales.—Dolbadarn Castle, Llyn Padarn, Snowdon, and Glyder Fawr, Carnarvonshire!

Scotland.—Sutherland, Aberdeen, Kincardine, Forfar, Perth, Dumbarton (*Roy & Bissett*). Renfrew!

Ireland.—Lough Guitane, Kerry! Dublin and Wicklow (*Archer*). Slieve Donard, Down!

Geogr. Distribution.—France. Germany. Bohemia and Galicia in Austria. Italy. Norway. Sweden. S. Russia. Faeroes. United States.

X. aculeatum is more widely distributed than *X. Brébissonii*, and is not an uncommon Desmid in the more mountainous parts of the British Islands. The spines are arranged in a continuous irregular band around the greatest circumference of the cell. The semicells vary somewhat in outline, and the apex may be slightly elevated (as in *Cosmarium ornatum*). The central protuberance is generally much less prominent than in *X. Brébissonii*, and also less granulated than in that species, while immediately above it there is often situated a spine or an emarginate wart.

The forms with very short spines—described as '*forma brevispina*'—have not yet been observed in the British Islands.

Var. **basidentatum** (Börg.) *nob.* (Pl. CXVII, figs. 23, 24.)

X. Brébissonii var. *basidentatum* Börg. Bidrag Bornh. Desm.-fl. 1889, p. 148, t. 6, f. 11; Roy & Biss. Scott. Desm. 1893, p. 244; Schmidle, Alg. Geb. Oberrheins, 1893, p. 552; Lütkem. Desm. Millstättersees, 1900, p. 14, t. 1, f. 15; Desm. Böhm. 1910, p. 496.

Semicells a little more angular, with a more prominently raised apex; spines irregular and much curved, showing a tendency to grouping at the angles; with a group of 2 or 3 flattened verrucæ just above but close to the sinus on each side.

Length without spines 60–78 μ, with spines 76–93 μ; breadth without spines 52–67 μ, with spines 68–83 μ; breadth of isthmus 20–23 μ; thickness 42–48 μ.

Scotland.—Near Dinnet, Aberdeen; Tent's Moor, Fife (*Roy & Bissett*).

Geogr. Distribution.—Germany. Austria. Bornholm.

This variety has been erroneously referred to *X. Brébissonii*, whereas the form of the semicells, the irregularity of the spines, and the nature of the central protuberance are all much more in agreement with *X. aculeatum*. Moreover, the semicells possess that raised apex which is not infrequently met with in *X. aculeatum*, but never in *X. Brébissonii*. The semicells of the latter species are proportionately wider and the spines are much more regularly disposed.

11. **Xanthidium variabile** (Nordst.) W. & G. S. West.

(Pl. CXIII, figs. 1–7.)

X. Smithii Arch. var. *variabile* Nordst. in Botan. Notis. 1887, p. 159; Freshw. Alg. N. Zeal. 1888, p. 44, t. 4, f. 27–29; West, Alg. W. Ireland, 1892, p. 166; W. & G. S. West, New and Int. Freshw. Alg. 1896, p. 156, t. 4, f. 40; Alg. S. England, 1897, p. 484; G. S. West, Variation Desm. 1899, p. 386, t. 8, f. 20–22.

X. variabile (Nordst.) W. & G. S. West, Notes Alg. II, 1900, p. 291; Alga-fl. Yorks. 1900, p. 68; Alg. N. Ireland, 1902, p. 31; Freshw. Alg. Ceylon, 1902, p. 160.

X. Westianum Gutw. Alg. Ins. Java, 1902, p. 590.

Cells small, about as long as broad, or a little longer, deeply constricted, sinus open and acute-angled; semicells rectangular-trapezoid, sides and apex almost straight, angles slightly rounded and furnished with 1–4 (commonly 3) very short, sharp spines (one of which is usually seen within the margin), central area small and strongly protuberant, usually almost papilliform, but sometimes broader and triangulate or even bispinate. Side view of semicell angular-subcircular, with a protuberance (sometimes emarginate or bispinate) at the middle on each side, and a small spine at each side of the apical margin. Vertical view elliptic, with a papilliform (or emarginate) protuberance at the middle on each side, poles rounded or subtruncate, trispinate (or rarely only bispinate). Cell-wall smooth. Chloroplasts axile, one in each semicell, with a central pyrenoid.

Zygospore globose, furnished with numerous short stout spines (or processes), trifid (rarely bifid) at the apex.

Length without spines 20–26 μ [–32 μ (*Nordstedt*)]; breadth without spines 18–23 μ [–28 μ (*Nordstedt*)]; length of spines 2–3 μ [–4 μ (*Nordstedt*)]; breadth of isthmus 6–8·6 μ; thickness 13·5–17 μ; diam. zygosp. without spines 29–31 μ, with spines 42–45 μ.

England.—Mickle Fell, N. Yorks! Devils' Jumps, Frensham (with zygospores), Esher Common, and Thursley Common, Surrey!

Ireland.—Dungloe, near Glenties, near Gweedore, Lough Machugh, and near Lough Glentornan, Donegal! Foxford and Clare Island, Mayo! Near Oughterard and Clifden, Galway! Torc Mountain, Cromagloun, and Carrantuohill, Kerry!

Geogr. Distribution.—Ceylon. Australia. New Zealand. British Guiana. Patagonia.

We regard *X. variabile* as one of the most distinctive species of the genus. It occurs in many parts of the British Islands, more especially in certain peaty *Sphagnum*-bogs, in which it is sometimes found in large numbers. It differs from *X. Smithii* in its somewhat smaller size, its much more protuberant central area, and in its much shorter and more irregular spines. These points of difference are retained very constantly, and not only does *X. variabile* never occur associated with *X. Smithii*, but no intermediate forms are known which in any way tend to connect these species. In fact we consider them to belong to different sections of the genus *Xanthidium*.

X. variabile exhibits a considerable amount of variation without losing any of its distinctive features. Each basal angle possesses three short spines which show most distinctly at the poles of the vertical view. The apical angles possess either two or three spines. The central protuberance in the great majority of specimens is in the form of a rather pronounced papilla, but it may be truncate-emarginate or even bispinate.

The poles of the vertical view were described by Nordstedt as truncate in the New Zealand specimens. In British examples, however, they are generally rounded, or rarely subtruncate. This is a point of little importance, although

Gutwinski, with his customary lack of perception, has seized upon it as a reason for naming the British specimens *X. Westianum*!

12. **Xanthidium Robinsonianum** Arch.

(Pl. CXIII, figs. 10–12; Pl. CXVIII, figs. 1–3.)

Xanthidium Robinsonianum Arch. in Q. J. Micr. Sci. n.s. xxii, 1880, pp. 114, 116; Joshua in Journ. Bot. xxi, 1883, p. 291; Wittr. & Nordst. Alg. Exsic. 1883, no. 550; Cooke, Brit. Desm. 1887, p. 134; De Toni, Syll. Alg. 1889, p. 924.

X. variabile (Nordst.) W. & G. S. West var. *complexum* W. & G. S. West, Alg. N. Ireland, 1902, p. 31, t. 2, f. 8.

Cells small, as long as broad, deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells widely pyramidate-trapeziform, apex straight or very faintly retuse, upper parts of sides slightly retuse, apical angles slightly rounded, basal angles broadly rounded; spines minute, variable in number and exact disposition, but mostly grouped at the angles and within the margin of the semicells, 2–4 at each angle and with groups of 2–3 within the margins, one of these groups almost invariably situated just below the middle of the apex; central area small and protuberant, furnished with 3–5 granules more or less irregularly disposed and sometimes connected by other acute granules with the small group of spines below the apex. Side view of semicell depressed-circular, with an emarginate protuberance on each side. Vertical view elliptic, with an emarginate protuberance at the middle on each side, poles rounded and furnished with 5–8 minute spines.

Zygospore globose, furnished with "delicately furcate, tuberculose" spines (*Joshua*).

Length without spines 22–25 μ, with spines 24–26·5 μ; breadth without spines 22–25 μ, with spines 24–28 μ; breadth of isthmus 6·5–8·5 μ; thickness 14·5–16 μ.

Wales.—Bog between Glyder Fach and the river Llugwy, Carnarvonshire!

Scotland.—N. of Barvas, Lewis, Outer Hebrides!

Ireland.—Near Glenties, and Glendoan, Donegal! Armagh (*Archer*). Kildare (*Crowe*). Glengariff, Cork (*Crowe*).

As in the case of so many other small Desmids discovered by Archer, the promised full description of *X. Robinsonianum* did not appear, so that the only information concerning it are the brief statements in the reports of the Dublin Microscopical Club. It is a very rare Desmid, which up to the present has been found nowhere in the world except in the western areas of the British Islands. Its exact identity was long uncertain, which accounts for the fact that we described it in 1902 as '*X. variabile* var. *complexum*.' Careful consideration, however, of the meagre information supplied by Archer, convinces us that the Desmid we have so described is *X. Robinsonianum*, and that another minute *Xanthidium* which we had described under the name of *X. Robinsonianum* is an undescribed species. This view was amply confirmed by an examination of the specimens issued in Wittrock and Nordstedt's 'Algæ Exsiccatæ,' No. 550, under the name of *X. Robinsonianum*. These are undoubtedly the Desmid which we described as *X. variabile* var. *complexum* and which we have since come to regard as *X. Robinsonianum*. We give some figures of these specimens (Pl. CXVIII, figs. 1–3) for comparison with those of specimens collected by ourselves.

In some individuals the central protuberance is furnished with three elongated and regularly disposed granules, but in others there are four or five smaller granules, and these are not infrequently connected with the small group of subapical spines by several acutely-pointed granules.

X. Robinsonianum differs from *X. variabile* in the shape of its semicells, in the closed sinus, and in the more numerous and differently grouped spines. The zygospore is also probably of a different character, but Joshua's remarks on the characters of the zygospore are very indefinite and he gives no figures. The zygospores were obtained from Derrystrasna Bog, Armagh.

13. **Xanthidium Orcadense** *sp. nov.*

(Pl. CXIII, figs. 10–12.)

Xanthidium Robinsonianum W. & G. S. West, New and Int. Freshw. Alg. 1896, p. 156, t. 3, f. 21, 22. [This is not *X. Robinsonianum* Arch.]

Cells small, as long as broad, deeply constricted, sinus open and acute-angled; semicells transversely

subrectangular, with convex lower margin, subparallel sides, and a slightly convex apex, *or* subpyramidate-trapeziform, with broadly rounded basal angles, and almost straight sides and apex; spines very minute, 1–2 at each superior angle and 1–4 at the margin of each basal angle, within the margins and towards the centre with a few irregularly disposed spines (or acute granules); central area protuberant but not thickened or granulate. Vertical view elliptic, with a small rounded protuberance at the middle on each side, poles rounded, each polar margin furnished with 3–6 minute spines.

Zygospore unknown.

Length without spines 18–27 μ; breadth without spines 16–24 μ; length of spines 0·8–1·2 μ; breadth of isthmus 5·5–9·7 μ; thickness 11·5–13 μ.

Scotland.—Orkneys!

We have only observed this small species from a *Sphagnum*-bog in the Orkney Islands, and in 1896 gave a description of it under the name of *X. Robinsonianum*. We now know that our identification was incorrect, and we therefore describe it as a new species. *X. Orcadense* differs from *X. Robinsonianum* in its open sinus, in its more scattered and more reduced spines, and in the rounded and less evident central protuberance.

14. **Xanthidium apiculiferum** West.

(Pl. CXIII, fig. 9.)

Xanthidium apiculiferum West, Alg. W. Ireland, 1892, p. 167, t. 24, f. 17; Nordst. Index Desm. 1896, p. 48.

Cells minute, as long as broad, deeply constricted, sinus narrow and slightly open; semicells very broadly pyramidate-trapeziform, angles slightly rounded and apex broadly truncate, inferior angles each furnished with a single minute spine, superior angles each furnished with a pair of minute spines, and with a similar pair in the middle of the apex, central area small and protuberant. Side view of semicell subcircular, with a small protuberance at the middle on

each side, and a pair of slightly divergent, minute spines at the apical margin. Vertical view elliptic, with one minute spine at each pole, and a small protuberance at the middle on each side.

Zygospore unknown.

Length without spines 11·5 μ, with spines 12·5 μ; breadth without spines 12 μ, with spines 12·5 μ; breadth of isthmus 5 μ; thickness 6·5 μ.

Ireland.—In small lake near Recess, Galway!

This little species should be compared with *X. concinnum* Arch., from which it differs in the form of its semicells and in the pair of minute spines in the middle of the truncate apex.

15. **Xanthidium concinnum** Arch.

(Pl. CXII, fig. 10.)

Xanthidium concinnum Arch. in Ann. Mag. Nat. Hist. ser. 5, xi, 1883, p. 285; Cooke, Brit. Desm. 1887, p. 189; Nordst. Index Desm. 1896, p. 78; W. & G. S. West, Alg. S. England, 1897, p. 484, t. 6, f. 15; Alga-fl. Yorks. 1900, p. 68; Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Lütkem. Desm. Böhm. 1910, p. 497.

Arthrodesmus hexagonus Boldt, Siber. Chlorophy. 1885, p. 109, t. 5, f. 16; De Toni, Syll. Alg. 1889, p. 1059; Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 64, t. 3, f. 9; Eichler in Pamiętnik fizyj. Akad. Umiej. Krakow, 1894, p. 130.

Xanthidium hexagonum (Boldt) Turner, Freshw. Alg. E. India, 1893, p. 137.

Cells minute, about as long as broad, deeply constricted, sinus narrow and linear; semicells transversely subhexagonal with a broad, truncate (or very slightly convex) apex, lateral angles each furnished with a single minute spine, apical angles each furnished with a pair of minute spines, central area small. Side view of semicell subcircular, with a small papilla at the middle on each side and a pair of minute spines at the apical margin. Vertical view elliptic, with a prominent papilla at the middle on each side, with one minute spine at each pole and a pair of minute spines on each side near the poles. Chloroplasts axile, with a single central pyrenoid in each semicell.

Zygospore unknown.

Length without spines 9–9·5 μ; breadth without

spines 9·5–10·5 μ; breadth of isthmus 2·5–3 μ; thickness 7 μ.

England.—Bog two miles S. of Clapham, W. Yorks! Puttenham and Thursley Commons, Surrey!

Wales.—Glyder Fach, Carnarvonshire!

Scotland.—Rhiconich, Sutherland! Orkneys! Shetlands!

Ireland.—Wicklow (*Archer*).

Geogr. Distribution.—Galicia and Bohemia in Austria. Siberia.

This minute Desmid, first described by Archer as *Xanthidium concinnum*, was afterwards described and figured by Boldt under the name of *Arthrodesmus hexagonus*. It is characterized by the hexagonal form of its semicells, by the single minute spine at each lateral angle, and the pair of similar minute spines at each apical angle. It should be compared most carefully with *Cosmarium pygmæum* Arch. (*vide* Vol. III, pp. 73–75, t. 71, figs. 22–31).

Var. **Boldtiana** West. (Pl. CXII, figs. 11, 12.)

Arthrodesmus hexagonus 'forma' Boldt Siber. Chlorophy. 1885, p. 109, t. 5, f. 17.

Xanthidium concinnum Arch. var. *Boldtiana* West, Alg. W. Ireland, 1892, p. 167, t. 22, f. 6; Roy & Biss. Scott. Desm. 1893, p. 244; W. & G. S. West, Alg. S. England, 1897, p. 484

Arthrodesmus hexagonus Boldt var. *polonica* Eichl. & Racib. in Rospraw Wydz. matem.-przy. Akad. Umiej. Krakow, xxvi, 1893, p. 122, t. 3, f. 6, 7.

Cells often less deeply constricted; semicells elliptic-hexagonal, without the apical pairs of minute spines.

Length 10–13 μ; breadth without spines 10–13·5 μ; breadth of isthmus 2·5–4 μ; thickness 8–10 μ.

England.—Thursley Common, Surrey!

Scotland.—Loch Ullachie near Ballater, Aberdeen (*Roy & Bissett*).

Ireland.—Near Oughterard, Galway! Moher Lough, Mayo! Lower Lake of Killarney, Kerry!

Geogr. Distribution.—Poland. Siberia. United States.

This variety differs from typical *X. concinnum* in the absence of the pairs of minute apical spines.

Genus 17. **ARTHRODESMUS** Ehrenb. 1838.

Ehrenb. in Arch. Naturg. Bd. II, 1836, p. 185 [name only]; Infus. 1838, p. 149.
Ralfs in Ann. Mag. Nat. Hist. xv, 1845, p. 150.
Hass. Brit. Freshw. Alg. 1845, p. 356.
Ralfs, Brit. Desm. 1848, p. 117.
Kütz. Spec. Algar. 1849, p. 176.
Arch. in Pritch. Infus. 1861, pp. 721, 736.
Rabenh. Flora Europ. Alg. III, 1868, p. 225.
Kirchn. Alg. Schles. 1878, p. 156.
Wolle, Desm. U. S. 1884, p. 95.
Cooke, Brit. Desm. 1887, p. 134.
Hansg. Prodr. Algenfl. Böhm. 1888, p. 202.
De Toni, Syll. Alg. 1889, p. 1056.
Turn. Freshw. Alg. E. India, 1893, p. 137.
G. S. West, Treatise Brit. Freshw. Alg. 1904, p. 170.

Cells mostly small, sometimes minute, usually about as broad as long, *invariably compressed* (except in the very rare triangular forms), symmetrical in three planes at right angles to each other; median constriction generally fairly deep, *sinus nearly always open*; semicells very generally obversely triangular, sometimes subquadrate and sometimes elliptic or subelliptic, *centre of semicell quite plane and undifferentiated*; vertical view elliptic, *with no median protuberances. Cell-wall furnished with simple spines disposed in a median plane*, one inserted at each lateral angle. Chloroplasts axile, generally one in each semicell, but subject to considerable variation, usually with one central pyrenoid.

Zygospores globose, smooth or furnished with simple, subulate spines.

The genus *Arthrodesmus* is closely related to *Xanthidium* and to certain of the spiny species of *Staurastrum*. It is primarily distinguished from *Xanthidium* by the absence from the semicells of any differentiated central area, and secondarily by the insertion of the spines in a median plane. Paired spines do not occur in the genus *Arthrodesmus* except in the one instance of *A. tenuissimus* Arch., in which the minute apical spines are paired. On the other hand, there are several species of *Xanthidium* in which all the spines are median and unpaired.

Some forms of certain species of *Staurastrum*, such as *St.*

jaculiferum var. *subexcavatum*, forms of *St. O'Mearii*, etc., and also some of the larger forms of *Arthrodesmus Incus*, are very confusing in their relationships, and are only placed with considerable difficulty. In some cases it is necessary to examine a large series of forms from various districts in order to arrive at a decision concerning the genus.

Just as there are fusiform or biradiate forms of *Staurastrum*, so there are triangular forms of *Arthrodesmus*, such as *A. triangularis* var. *subtriangularis* forma *triquetra* (*cf.* Pl. CXV. fig. 4).

Notwithstanding the difficulties concerned with the placing of these transitional forms, and the fact that its definition cannot be made very exact, the genus *Arthrodesmus* is a great convenience for the reception of those Desmids which do not rightly belong either to *Staurastrum* or *Xanthidium*.

The genus has been subdivided into the sections '*Tetracanthium*' and '*Octacanthium*' by Hansgirg, into *Euarthrodesmus*' and '*Centrenterium*' by Raciborski (who included Boldt's subgenus of *Xanthidium*), and into '*Aplodesmus*' and '*Schizodesmus*' by Turner. It is not possible, after a careful consideration of the species of this genus, to accept the suggestions either of Raciborski or of Turner, but Hansgirg's two sections are quite satisfactory for most species of the genus. To these we have added a third section for the reception of the species which do not appear to have been sufficiently well studied by the above-mentioned authors.

Both Borge and Lütkemüller have suggested that *Ichthyocercus* should probably be placed as a section of *Arthrodesmus*, but that genus is nearest to *Tetmemorus* and has no close affinity with *Arthrodesmus*.

Section A. Semicells with a single spine on each side, attached to the lateral angle. [*Tetracanthium* (Näg.) Hansg.]

* Semicells obsemicircular or in the form of an inverted triangle, sinus open.

† Angles of semicells furnished with long or very long spines.

‡ Apex of semicell straight or convex (or very faintly concave), spines very rarely horizontal, usually divergent, rarely convergent.

1. *A. Incus.*

‡‡ Apex of semicell elevated, and retuse in the middle (except in one variety), spines horizontal.

2. *A. triangularis.*

‡‡‡ Apex of semicell retuse in the middle, spines of great length and widely divergent.

3. *A. quiriferus.*

†† Angles of semicells furnished with very short spines, often merely mucronate.

‡ Apex of semicell convex.

§ Cells small, vertical view rhomboid.

4. *A. crassus.*

§§ Cells minute, vertical view elliptic.

5. *A. controversus.*

‡‡ Apex of semicells retuse, making the semicells triangular-lunate.

6. *A. phimus.*

** Semicells subrectangular, sinus closed and linear.

7. *A. Pylaheimii.*

*** Semicells elliptic or narrowly elliptic.

† Spines rather short and incurved, sinus closed at the apex and opening outwards.

8. *A. convergens.*

†† Spines longer and disposed horizontally, sinus open from the extreme apex.

9. *A. subulatus.*

Section B. Semicells with two spines on each side, one attached to each of the two lateral angles. [*Octacanthium* Hansg.]

* Semicells rectangular with retuse sides, spines fairly long.

10. *A. octocornis.*

** Semicells hexagonal depressed, spines short.

11. *A. bifidus.*

Section C. Semicells with three spines on each side.

* Three spines in the same vertical plane.

12. *A. trispinatus.*

** Three spines not in the same plane; one lateral and two apical, the latter forming a pair in a horizontal plane.

13. *A. tenuissimus.*

1. **Arthrodesmus Incus** (Bréb.) Hass.

(Pl. CXIII, figs. 13–15.)

Binatella Incus Bréb. Alg. Falaise, 1835, p. 269.

Heterocarpella Incus Bréb. in Cheval. microscop. et usage, 1839, p. 272.

Staurastrum Incus (Bréb.) Menegh. Synops. Desm. 1840, p. 228; Ralfs in Ann. Mag. Nat. Hist. 1845, xv, p. 158, t. 12, f. 2; Jacobs. Desm. Danem. 1876, p. 204 [in part].

Arthrodesmus Incus (Bréb.) Hass. Brit. Freshw. Alg. 1845, p. 357, t. 85, f. 10; Ralfs, Brit. Desm. 1848, p. 118, t. 20, f. 4 *a–d*; Arch. in Pritch. Infus. 1861, p. 737 [in part]; Rabenh. Flor. Europ. Alg. III, 1868, p. 226 [in part]; Nordst. Desm. Brasil. 1870, p. 231; Kirchn. Alg. Schles. 1878, p. 156; Wolle Desm. U. S. 1884, p. 97, t. 24, f. 5 (?); Boldt, Siber. Chlor. 1885, p. 109; Cooke, Brit. Desm. 1887, p. 135, t. 47, f. 4 [in part]; Hansg. Prodr. Algenfl. Böhm. 1888, p. 202; Boldt, Desmid. Grönland, 1888, p. 30; Nordst. Freshw. Alg. N. Zeal. 1888, p. 45; De Toni, Syll. Alg. 1889, p. 1057; West, Alg. W. Ireland, 1892, p. 168; Alg. Engl. Lake Distr. 1892, p. 730; Lütkem. Desm. Attersees,

1893, p. 559; Roy & Biss. Scott. Desm. 1894, p. 40; Nordst. Index Desm. 1896, p. 145; W. & G. S. West, Alg. S. England, 1897, p. 496; Alga-fl. Yorks. 1901, p. 109; Börg. Freshw. Alg. Færoës, 1901, p. 228; W. & G. S. West, Alg. N. Ireland, 1902, p. 58; Hirn, Desm. Finland, 1903, p. 5; W. & G. S. West, Scott. Freshw. Plankton, I, 1903, p. 527; Borge, Alg. erst. Regnell. Exped. II. Desmid. 1903 p. 103; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Further Contrib. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, p. 85; Borge, Beiträge Alg. Schweden, 1906, p. 49; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 324; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181; Phytoplankton Engl. Lake District, 1909, p. 138.

Euastrum retusum Kütz. Phyc. germ. 1845, p. 136.

Cosmarium Incus De Bary, Conj. 1858, p. 72.

C. retusum (Kütz.) Rossmann in Jahresber. d. Wetterau. Ges. f. die gesammte Naturkunde zu Hanau, 1861, p. 7.

Arthrodesmus Incus b. Lund. Desm. Suec. 1871, p. 55.

Didymidium erectum Reinsch, Algenfl. Frank. 1867, p. 157 (in part).

Arthrodesmus Incus var. *divergens* Cooke, Brit. Desm. 1887, p. 136; West, Alg. N. Wales, 1890, p. 291.

A. Incus forma *typica* Heimerl, Desm. alp. 1891, p. 603, t. 5, f. 17; Lütkem. Desm. Millstättersees, 1900, p. 13.

Cells rather small, a little longer than broad (without the spines), deeply constricted, sinus widely open and sometimes submamillate at the extremity; semicells obversely triangular or obversely subtrapeziform-triangular, apex straight, rarely slightly concave, sides very faintly convex, each angle only slightly rounded and furnished with an elongated, stout, diverging spine. Vertical view elliptic, each pole furnished with a long, stout spine. Cell-wall smooth. Chloroplasts axile, one in each semicell, sometimes containing a conspicuous pyrenoid.

Zygospore not definitely known, but probably furnished with simple spines.

Length without spines 21–27 μ, with spines 44–50 μ; breadth without spines 18–23 μ, with spines 56–71 μ; length of spines 20–28 μ; breadth of isthmus 7–9 μ; thickness 10–11·5 μ.

England.—Cumberland! Westmoreland! Surrey! Cornwall! In the plankton of Buttermere, Ennerdale Water, and Bassenthwaite Water, Cumberland! In the plankton of Easdale and Codale Tarns, Westmoreland!

Wales.—In the plankton of several of the lakes of Carnarvonshire!

Scotland.—Sutherland! Inverness! Perth! Ayr! Lewis and Harris, Outer Hebrides!

Ireland.—Donegal! Galway! Mayo! Kerry! Cork!

Geogr. Distribution.—(The following distribution most certainly includes the records of forma *minor*, var *indentatus*, and var. *Ralfsii*). France. Belgium. Germany. Austria. Italy. Norway. Sweden. Denmark. Bornholm. Finland. Poland. S. Russia. Færoes. Iceland. Greenland. India. Java. New Zealand. Australia. United States. Cuba (var.). W. Indies (var.). Guiana. Brazil. Paraguay. Patagonia.

Arthrodesmus Incus has numerous varieties, some of which are distributed all over the world. It is very probable that many of the records given above refer to one or more of the following varieties and not to what we consider the type form. We have regarded the form described above as the type form for two reasons. In the first place, most of the forms of this Desmid are fairly stout with long divergent spines; and secondly, this form is nearest to certain forms of *Staurastrum* from which it is probable that *Arthrodesmus Incus* originated. It is, so far as we can judge, the least specialized of all the forms of *A. Incus*.

Some of the long-spined forms with distinctly triangular semicells appear to form a graduated series with the biradiate forms of *Staurastrum jaculiferum*, and other species of *Arthrodesmus* are closely related to certain of the triangular spiny species of *Staurastrum*. In fact, there seems little doubt that the majority of the species of *Arthrodesmus* have arisen from certain species of *Staurastrum* by the adoption of a permanent biradiate character.

In certain individuals we have noticed that through the larger pores in the cell-wall a tough mucilage is excreted, which assumes the form of blunt or emarginate processes standing out at right angles to the surface of the wall and disposed one over each pore. These mucilaginous processes occasionally turn yellow or even brown in colour and become quite hard. (Consult Pl. CXIII, fig. 15; also Pl. CXIV, fig. 5 *c*.)

Forma **minor** *nob.* (Pl. CXIII, figs. 16–19.)

Arthrodesmus Incus of very many authors.

Cells not much more than half the size of the type,

very slightly inflated so that both sides and apex of semicells are a little convex; cell-wall thinner; spines considerably shorter and not so robust.

Zygospore subglobose, furnished with simple, acute spines.

Length without spines 12·5–16·5 μ, with spines 19–25 μ; breadth without spines 12·5–13·5 μ, with spines 19–26 μ; length of spines 4–9 μ; breadth of isthmus 5·5–7 μ; thickness 7–8·5 μ; diam. zygosp. without spines 19 μ, with spines 33–37 μ.

England.—Cumberland! Westmoreland (zygospores from several localities)! W. and N. Yorks. (zygospores from near Halifax and in bog 2 miles S.W. of Clapham)! Cheshire (*Roy*). Leicestershire (*Roy*). Warwick! (*Wills*). Gloucester! Surrey (zygospores from Chobham and Esher Commons)! Sussex! Hants! Devon! Cornwall!

Wales.—General (zygospores frequent in Carnarvonshire and Merioneth)!

Scotland.—General! (*Roy & Bissett*). Frequently conjugated! Lewis, Harris, N. and S. Uist, and Benbecula, Outer Hebrides! Orkneys! Shetlands! Frequent in the plankton!

Ireland.—Very frequent (zygospores not uncommon)!

Geogr. Distribution.—Consult that under the type form, which it has been impossible to unravel.

This small form is perhaps one of the most abundant forms of *Arthrodesmus Incus* met with in the British Islands, and is certainly the most frequent one observed with zygospores. It is sufficiently distinct by reason of its small size and more delicate spines. It is found principally amongst *Sphagnum*, both in bogs and pools.

Forma **perforata** Schmidle. (Pl. CXIV, fig. 1.)

Arthrodesmus Incus forma *perforata* Schmidle, Lappmark Süsswasseralgen, 1898, p. 42, t. 2, f. 11.

Spines shorter; cell-wall with a few scattered, irregularly disposed scrobiculations.

Length without spines 31 μ, with spines 45 μ; breadth without spines 26 μ, with spines 56 μ; breadth of isthmus 12·5 μ.

Wales.—Llyn Idwal, Glaslyn, and Llyn-y-Ddinas, Carnarvonshire!

Geogr. Distribution.—Lappmark in Norway.

The scrobiculations on the cell-wall of this form are doubtless situated each under the base of one of the mucilaginous processes which have already been mentioned.

Var. **indentatus** *var. nov.* (Pl. CXIII, figs. 20–24.)

Sides of semicells indented just above the isthmus, making the semicell tranversely subrectangular in its upper greater portion and somewhat cup-shaped in its lower lesser portion; spines long and stout, generally divergent but more rarely horizontal. Cell-wall sometimes irregularly and sparsely scrobiculate.

Length without spines 26–31 μ; breadth without spines 18–22 μ; length of spines 17·5–26 μ; breadth of isthmus 7–9 μ.

England.—Cumberland! Westmoreland! N. Yorks! Cornwall!

Wales.—Capel Curig, Llyn Ogwen, Llyn Idwal, Llyn-y-cwm-ffynon, and Glyder Fach, Carnarvonshire! Dolgelly, Merioneth.

Scotland.—Sutherland! Perth! Forfar! Aberdeen! Lewis and Harris, Outer Hebrides!

Ireland.—Donegal! Down! Mayo! Galway! Kerry! Cork!

This is one of the most frequent British varieties, occurring principally at the boggy and weedy margins of lakes. It is somewhat variable in the length and divergence of its spines, but the slight constriction of the basal part of the semicell is a very constant feature. Some of the cells are irregularly scrobiculated, somewhat as in *A. Incus* forma *perforata*, and these might be known as 'forma *scrobiculata*' (Pl. CXIII, fig. 24).

It is possible that this variety is identical with *A. Incus* forma *isthmosa* Heimerl ('Desm. alp.' 1891, p. 603, t. 5, f. 18)

but Heimerl's figures do not show the character upon which we have founded this variety.

Var. **Ralfsii** W. & G. S. West. (Pl. CXIV, figs. 2–4.)

Arthrodesmus Incus var. β Ralfs, Brit. Desm. 1848, p. 118, t. 20, f. 4 *e–h*.
? *A. Incus* forma *Brébissonii* Racib. Desm. Nowe, 1889, p. 96, t. 6, f. 15.
A. Ralfsii Wes , Alg. W. Ireland, 1892, p. 168; Alg. Engl. Lake Distr. 1892, p. 730; W. & G. S. West, Alg. S. England, 1897, p. 497.
A. Incus var. *vulgaris* Eichl. & Racib. in Rospraw. Spraw. Wydz. matem.-przyr. Akad. Umiej. Krakow, xxvi, 1893, p. 119.
A. Incus var. *Ralfsii* W. & G. S. West, Alga-fl. Yorks. 1901, p. 109; Alg. N. Ireland, 1902, p. 58; Scott Freshw. Plankton, I. 1903, p. 528; Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Cushman in Rhodora, vii, 1905, p. 261; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Cushman in Bull. Torr. Bot. Club, xxxiii, 1907, p. 613; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181; Phytoplankton Engl. Lake Distr. 1909, p. 138.
? *Staurastrum Sarsii* var. *longispinum* Huitfeldt-Kaas, Plankton. Norske Vande, 1906, p. 56, t. 1, f. 18, 19.

Semicells trapeziform, with the sides somewhat upwardly diverging and a straight or slightly concave apex. Sinus a small rounded excavation. Spines of moderate size and slightly convergent.

Zygospore globose, furnished with long, simple spines.

Length 27–33 μ; breadth without spines 18–20 μ, with spines 44–47 μ; breadth of isthmus 7·5–9·5 μ; diam. zygosp. without spines 19 μ, with spines 35 μ.

England.—Westmoreland! W., N., and E. Yorks! Warwicks! Essex! Surrey! Devonshire! Cornwall! In the plankton of Codale and Easdale Tarns, Westmoreland!

Wales.—Capel Curig, and in the plankton of Llyn Ogwen, Carnarvonshire!

Scotland.—Perth! Aberdeen! Inverness! Forfar! Sutherland! In the plankton of Loch Fadaghoda, Loch Roinebhall, and Loch Shubhaill, Lewis; and Loch a Bhursta, Benbecula, Outer Hebrides! Orkneys!

Ireland.—Donegal! Roundstone and Lough Derryclare, Galway! Near Lough Brin, Kerry! Castletown and Adrigole, Cork!

Geogr. Distribution.—Sweden. Greenland. (Consult also the distribution given under the type.)

This variety is widely distributed in the British Islands, and several distinct forms of it can be recognized apart from the one originally figured by Ralfs. Two of these we have named as follows:—

Forma LATIUSCULA (Pl. CXIV, fig. 5). Cells proportionately wider and isthmus broader; spines shorter. Length 18–20 μ; breadth without spines 19–23 μ, with spines 31–34 μ; breadth of isthmus 9–10 μ.

Forma SUBHEXAGONA (Pl. CXIV, fig. 6). Smaller; semicells subhexagonal-elliptic, spines very short. Length 15·4 μ; breadth without spines 15 μ; length of spines 3–3·8 μ; breadth of isthmus 7·5 μ. This form has been described and figured as *A. Incus* var. *Ralfsii* forma spinis brevissimis W. & G. S. West, 'Further Contrib. Freshw. Plankton Scott. Lochs,' 1905, p. 501, t. 7, f. 10. It would appear also to be identical with *Staurastrum dejectum* Bréb. var. *Debaryanum* (Jacobs.) Nordst. forma Borge, 'Beiträge Alg. Schweden,' 1906, p. 44, t. 3, f. 36.

Var. **validus** W. & G. S. West. (Pl. CXIV, figs. 9, 10.)

A. Incus var. *validus* W. & G. S. West, Some Desm. U. S. 1898, p. 320, t. 17, f. 16; Freshw. Alg. Ceylon, 1902, p. 192; Cushman in Rhodora, vii, 1905, p. 260.

Cells large; semicells obversely subsemicircular with an almost straight apex; spines very stout and long, strongly divergent.

Length without spines 33–35 μ, with spines 84–111 μ; breadth without spines 29–36 μ, with spines 50–76 μ; length of spines 27–42 μ; breadth of isthmus 8·5–9 μ.

SCOTLAND.—Rhiconich, Sutherland!

IRELAND.—Near Foxford, Mayo!

Geogr. Distribution.—Ceylon. United States.

This is the stoutest of the varieties of *A. Incus*, and in the largest forms the bases of the spines are hollow (consult Pl. CXIV, f. 9).

Var. **longispinus** Eichl. & Racib. (Pl. CXIV, fig. 8.)

A. Incus Wolle, Desm. U. S. 1884, t. 24, f. 3.

A. Incus forma *longispina* Eichl. & Racib. in Rospraw. Spraw. Wydz. matem.-przyr. Akad. Umiej. Krakow, xxvi, 1893, p. 120, t. 3, f. 21.

A. Incus var. *longispinus* W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 501, t. 7, f. 22; Cushman in Rhodora, vii, 1905, p. 260.

A small variety with the spines very long and upwardly divergent to the same extent as in var. *validus*.

Length without spines 14 μ; breadth without spines 11·5 μ; length of spines 21–25 μ; breadth of isthmus 5·7 μ.

Scotland.—Small loch near Cearnabhall, Lewis, Outer Hebrides (in the plankton)!

Geogr. Distribution.—Poland. United States.

This variety is well characterized by the great length of the spines as compared with the size of the cell-body.

Var. **subquadratus** W. & G. S. West. (Pl. CXIV, fig. 7.)

? *A. Incus* forma *quadrata* Schmidle, Beitr. alp. Alg. 1896, p. 26 (sep.), t. 16, f. 10.

A. Incus var. *subquadratus* W. & G. S. West, Alg. S. England, 1897, p. 496, t. 7, f. 20.

A small variety with the cells much less constricted than usual; semicells subquadrate or rectangular-quadrate, sides and apex very slightly convex.

Length without spines 15–17 μ; breadth without spines 11 μ; length of spines 5·5–7 μ; breadth of isthmus 7·5 μ; thickness 8 μ.

England.—Chobham Common, Surrey!

It is possible that "forma *quadrata*" described by Schmidle from the Tyrol is identical with this variety, but Schmidle's figure is poor. His description reads "aculeis divergentibus, apicibus truncato-rotundatis, lateribus fere parallelis vix vel non concavis."

2. **Arthrodesmus triangularis** Lagerh.

(Pl. CXIV, figs. 11–13, 17.)

Arthrodesmus triangularis Lagerh. Bidr. Amerik. Desm.-fl. 1885, p. 244, t. 27, f. 22; De Toni, Syll. Alg. 1889, p. 1061; Racib. Desm. Tapakoomas. 1895, p. 33; W. & G. S. West, Alg. N. Ireland, 1902, p. 58; Scott. Freshw. Plankton, I. 1903, p. 528; Freshw. Alg. Orkneys and Shetlands, 1905, p. 24; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Freshw. Alg. Burma, 1907, p. 211, t. 15, f. 7; Brit. Freshw. Phytoplankton, etc., 1909, p. 181; Phytoplankton Engl. Lake Distr. 1909, p. 138.

? *A. Incus* forma *rotundata* Racib. Desm. Nowe, 1889, p. 96, t. 6, f. 16.

A. Incus var. *triangularis* Lagerh. in Nuova Notarisia, IV, 1893 p. 182.

Cells rather small, a little longer than broad (without the spines), deeply constricted, sinus a wide (often almost semicircular) excavation, isthmus generally elongated and shortly cylindrical; semicells obversely triangular, apex elevated and convex, retuse in the median part, sides slightly convex, each lateral angle slightly rounded and furnished with a long horizontally-placed spine. Vertical view elliptic, each pole with a long spine. One axile chloroplast in each semicell containing a single pyrenoid.

Zygospore unknown.

Length (without spines) 23–30 μ; breadth without spines 19–25 μ; length of spines 12·5–25 μ; breadth of isthmus 5–7 μ; thickness 7·8–9 μ.

England.—Plankton of Ennerdale Water and Crummock Water, Cumberland! Plankton of Grasmere, Westmoreland!

Wales.—Near Conway and Llyn Elsie, Carnarvonshire!

Scotland.—Plankton of Lochs Katrine and Achray, Perth! In the plankton of Loch na Cloiche Sgoilt, Inverness! Loch Beosetter, Bressay, Shetlands!

Ireland.—Near Glenties and near Lough Glentornan, Donegal! Ballynahinch, Galway!

Geogr. Distribution.—Galicia in Austria. Bengal. Burma. United States. Brazil. Guiana.

In arranging the British species of *Arthrodesmus* we have considered it most advisable to retain *A. triangularis* and its allied forms as a separate species-group. All these forms constitute a very natural series, easily recognizable and well demarcated from the numerous forms of *A. Incus* by the form of the semicells and the horizontal disposition of the long spines. Perhaps the most distinctive feature of *A. triangularis* is the elevated apex of the semicells, a character which is only possessed by one form of *A. Incus*, namely, *A. Incus* var. *Ralfsii* forma *subhexagona*.

We find this species much more abundant in the plankton than in any other situations, and in many of these plankton-forms the cells are often conspicuously twisted at the isthmus (*vide* Pl. CXIV, fig. 17).

Forma **triquetra** *nob.* (Pl. CXXVIII, fig. 16.)

Staurastrum dejectum Bréb. subsp. *Tellamii* W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 11, t. 2, f. 45; Alg. S. England, 1897, p. 492.

Vertical view triangular with retuse sides.

Length (without spines) 21 μ; breadth without spines 21 μ, with spines 48 μ; breadth of isthmus 6·5 μ.

England.—Gunwen Moor, Cornwall!

This Desmid has little in common with *Staurastrum dejectum*, whereas in front view it agrees very closely with some forms of *A. triangularis*. It is in transitional forms of this kind that the distinction between the genera *Arthrodesmus* and *Staurastrum* breaks down. The occurrence of such forms, however, does not seriously interfere with the view that it is expedient to retain the genus *Arthrodesmus*.

Var. **inflatus** W. & G. S. West. (Pl. CXIV, figs. 14–15.)

A. triangularis forma West, Alg. W. Ireland, 1892, p. 168, t. 24, f. 19.
A. triangularis var. *inflatus* W. & G. S. West, Some Desm. U. S. 1898, p. 320; Cushman in Rhodora, vii, 1905, p. 261.

Semicells much inflated, angular-elliptic, apices elevated and generally slightly truncate or faintly retuse in the middle, more rarely entirely convex; spines stronger and very slightly divergent. Isthmus very shortly cylindrical.

Length 24–38 μ; breadth without spines 19–25 μ, with spines 57–72 μ; breadth of isthmus 5·8–7·5 μ; thickness 10·5–12·5 μ.

Wales.—Llyn Idwal, Carnarvonshire!

Scotland.—Bressay, Shetlands!

Geogr. Distribution.—United States.

This form occurs chiefly in the plankton and is readily distinguished by its inflated semicells.

In the plankton of Cwellyn, Carnarvonshire, some large forms with longer and stouter spines have been observed. These we have named "forma robusta." Length 32–37 μ; breadth without spines 26·5–27·5 μ, with spines 100–105 μ; breadth of isthmus 8–8·7 μ. (Pl. CXIV, fig. 16).

Var. **subtriangularis** (Borge) W. & G. S. West. (Pl. CXV, figs. 1–3.)

A. Incus var. *subtriangularis* Borge, Algologiska Notiser, 1897, p. 212, t. 3, f. 4.
A. triangularis var. *hebridarum* W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 542.
A. triangularis var. *subtriangularis* (Borge) W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 24, t. 2, f. 36; Further Contrib. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, p. 85; British Freshw. Phytoplankton, etc., 1909, p. 181; Phytoplankton Engl. Lake Distr. 1909, p. 138.
A. granulatus Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 324, t. 7, f. 7.

Slightly larger, with more robust semicells as in var. *inflatus*; lower margins of semicells indented just above the isthmus; apex much elevated, convex, but retuse in the middle; cell-wall commonly possessing a number of irregularly scattered scrobiculations.

Length 30–42; breadth without spines 23–32 μ; with spines 75–84·5 μ; breadth of isthmus 8–8·5 μ.

England.—In the plankton of Ennerdale Water and Thirlmere, Cumberland! Plankton of Codale and Easdale Tarns, Westmoreland!

Wales.—Plankton of Llynau Dywaunedd, Carnarvonshire!

Scotland.—Frequent in the Scottish plankton, especially in the lakes of Sutherland, Ross, Inverness, Argyll (*Borge*), and the Outer Hebrides! Shetlands!

Ireland.—Lakes near Recess, and between Clifden and Roundstone, Galway!

Geogr. Distribution.—West Greenland.

This northern variety of *A. triangularis* appears to be mostly confined to the plankton. In the "pinched-in" character of the semicells just above the isthmus it is strictly analogous to the var. *indentatus* of *A. Incus*. The scrobiculations on the cell-wall are variable both in number and disposition, and are sometimes very indistinct.

A most interesting form with triangular semicells (in vertical view) occurred in the plankton of Easedale Tarn, Westmoreland. This we have named forma triquetra W. & G. S. West, 'Phytoplankton Engl. Lake Distr.' 1909, p. 288, and text-fig. 5 *d*. (Pl. CXV, fig. 4). It is another of those connecting forms between the genera *Arthrodesmus* and

Staurastrum, and some individuals were observed in which one semicell was of the normal elliptic form whereas the other was triangular (*vide* Pl. CXV, fig. 5).

The recently described *A. granulatus* Larsen, which, by the way, is scrobiculate and not granulate, is merely an arctic form of this variety in which the spines are a little reduced.

3. **Arthrodesmus quiriferus** W. & G. S. West.

(Pl. CXV, figs. 6, 7.)

Arthrodesmus quiriferus W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 542, t. 17, f. 9, 10; Brit. Freshw. Phytoplankton, etc., 1909, p. 181.

Cells of medium size, a little longer than broad (without spines), fairly deeply constricted, sinus very widely open and rounded; semicells obversely subtriangular with convex sides and a widely concave apex, each angle furnished with a strong, straight, divergent spine of great length. Vertical view elliptic with a strong, long spine at each pole. Cells usually twisted at the isthmus.

Zygospore unknown.

Length without spines 28–31 μ; breadth without spines 21–23 μ; length of spines 31–44 μ; breadth of isthmus 6–9·5 μ; thickness 10–11 μ.

Scotland.—In the plankton of Loch Shin, Sutherland! In the plankton of Loch Laxadale, Harris, Outer Hebrides!

In the plankton of Loch Shin this species was very abundant. It is distinguished from the biradiate form of *Staurastrum jaculiferum* by the outward form of the cells, with retuse apices, and by the longer spines. The cells are almost invariably twisted at the isthmus.

Forma **compacta.** (Pl. CXV, fig. 18.)

Semicells stouter, sinus not quite so widely open and rather narrowed towards the extremity; spines not quite so long.

Length without spines 30 μ; breadth without spines

28 μ; length of spines 31–36 μ; breadth of isthmus 9·5 μ.

Hab.—In the plankton of Loch Shin, Sutherland!

4. **Arthrodesmus crassus** W. & G. S. West.

(Pl. CXV, figs. 8–11.)

Arthrodesmus crassus W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 541, t. 14, f. 8, 9; Further Contrib. Plankton Scott. Lochs, 1905, p. 485; Comp. Study Plankton Irish Lakes, 1906, p. 85; Nordst. Index Desmid. Supplem. 1908, p. 43; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181; Phytoplankton Engl. Lake Distr. 1909, p. 288, fig. 5 B.

Staurastrum Sarsii Huitfeldt-Kaas, Plankton. Norske Vande, 1906, pp. 55, 156, t. 1, f. 11–17 [figures incorrect].

Cells small, about as long as broad (without the spines), moderately constricted, sinus very widely open and slightly acuminate; semicells obversely subtriangular, sides very slightly convex, apex widely convex, each angle furnished with a very short acute spine. Vertical view broadly elliptic-fusiform, poles acute and furnished with a very short spine. Chloroplasts axile, one in each semicell with a single central pyrenoid.

Zygospore unknown.

Length 19·5–24 μ; breadth without spines 19–23 μ; length of spines 1·5 μ; breadth of isthmus 9·5–12·5 μ; thickness 11·5–13 μ.

England.—Plankton of Ennerdale Water, Cumberland; and Hawes Water, Westmoreland!

Scotland.—Plankton of Lochs Cuthaig, Fadaghoda, Mor Bharabhais, and Roinebhall, Lewis, Outer Hebrides!

Ireland.—Plankton of Lough Currane, Kerry!

Geogr. Distribution.—Norway.

This characteristic plankton-species is found in all the British lake-areas except the Welsh, in which it has not yet been observed.

It is of the same size as the Brazilian *A. psilosporus* Nordst. & Löfgr. (in Wittr. & Nordst. 'Alg. Exsic.' 1883, no. 558), but is relatively shorter, and the semicells are never retuse

either at the sides or the apex; the vertical view has also more acute poles.

In its general form *A. crassus* agrees fairly well with *A. controversus* W. & G. S. West, but the latter is very much smaller and more delicate, with a broadly elliptic vertical view.

This species sometimes occurs in great abundance in the plankton, the cells secreting a large quantity of mucus. The fibrillar structure of this mucus was described by Huitfeldt-Kass in 1906 as an armature of spines.

5. **Arthrodesmus controversus** W. & G. S. West.

(Pl. CXV, figs. 12–14.)

Arthrodesmus ? glaucescens Wittr. forma *convexa* West, Alg. W. Ireland, 1892, p. 170, t. 22, f. 10; Alg. Engl. Lake Distr. 1892, p. 730, t. 9, f. 27; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 324.

A. controversus W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 9; Nordst. Index Desm. 1896, p. 81; W. & G. S. West, Alg. N. Ireland, 1902, p. 59.

Cells minute, a little longer than broad (without the spines), moderately constricted, sinus obtuse-angled and very widely open, with an acuminate apex; semicells obversely subtriangular or cuneate, sides and apex convex, angles furnished with a very minute short spine. Side view of semicell subcircular. Vertical view broadly elliptic, with a very minute spine at each pole. Cell-wall smooth.

Zygospore globose, furnished with long, simple spines.

Length 10·5–12 μ; breadth without spines 10–11·5 μ, with spines 11–13·6 μ; breadth of isthmus 5–5·9 μ; thickness 5·5–6·5 μ; diam. zygosp. without spines 16·5 μ, with spines 29 μ.

England. — Hawkshead, Lancashire ! Wastdale, Cumberland (with zygospores) !

Ireland.—Near Lough Magrath, Donegal ! Slieve Donard, Down ! Creggan Lough, Mayo ! Adrigole, Cork !

The minute plant originally described by Wittrock as "*Arthrodesmus ? glaucescens*" has since been found to belong to the genus *Tetrapedia*. As this minute alga is a typical Desmid in every respect, and conjugates to form

spiny zygospores, it was necessary that it should be renamed.

A. controversus is probably the smallest species of the genus. It resembles *A. crassus* in outward form, but is much smaller and more delicate, and the vertical view is elliptic with broadly rounded poles.

6. **Arthrodesmus phimus** Turn.

(Pl. CXV, figs. 15, 16.)

Arthrodesmus phimus Turn. Freshw. Alg. E. India, 1893, p. 136, t. 12, f. 9; Nordst. Index Desmid. 1896, p. 200; W. & G. S. West, Freshw. Alg. Ceylon, 1902, p. 192, t. 22, f. 21.

Cells small, about as long as broad (without the spines), sometimes longer, sometimes broader, deeply constricted, sinus subrectangular with a rounded or an acuminate extremity; semicells obversely subtriangular or widely cuneate, sides convex, apex widely retuse, each angle slightly rounded and furnished with a very short divergent spine. Vertical view narrowly elliptic, poles rounded, each with a very short spine. Cell-wall smooth.

Zygospore unknown.

Length 19·5–26 μ; breadth without spines 20–25·5 μ; length of spines 3–4 μ; breadth of isthmus 6·5–7·5 μ.

Geogr. Distribution.—India. Ceylon.

The typical form of this species is not known to occur in the British Islands.

Var. **occidentalis** W. & G. S. West. (Pl. CXV, fig. 17.)

A. phimus var. *occidentalis* W. & G. S. West, Alg. N. Ireland, 1902, p. 59, t. 2, f. 17.

A small variety, with the cells broader than long, the angles less produced, and the sinus somewhat less open.

Length 14–14·6 μ; breadth without spines 16·3–17·3 μ, with spines 19–19·4 μ; breadth of isthmus 5·7–6·2 μ; thickness 7·2 μ.

Ireland.—Lough Anna, Donegal!

Var. **hebridarum** *var. nov.* (Pl. CXVII, fig. 22.)

A small variety, with the angles of the semicells somewhat produced and narrower; sides of semicells faintly retuse, and apex very slightly convex in the middle portion only.

Length 15 μ; breadth without spines 18·5 μ, with spines 21·5 μ; breadth of isthmus 6 μ.

Scotland.—Benbecula, Outer Hebrides!

7. **Arthrodesmus Bulnheimii** Racib.

(Pl. CXVI, figs. 1, 2.)

Arthrodesmus Incus Bulnh. in Hedwigia, 1861, p. 51, t. 9, f. 3.
A. Bulnheimii Racib. Desm. Nowe, 1889, p. 95, t. 16, f. 17; Eichler, Mat. flor. Miedz. 1894, p. 129, t. 3, f. 34; Nordst. Index Desmid. 1896, p. 70.

Cells of medium size, or sometimes less, a little longer than broad (without the spines), deeply constricted, sinus narrowly linear with a slightly dilated apex; semicells transversely subrectangular, sometimes very slightly widened from base to apex, sides and apex slightly convex, angles slightly rounded, each apical angle furnished with a long, stout, divergent spine. Cell-wall smooth, punctate, or more rarely with a few irregularly scattered scrobiculations. Vertical view elliptic with a stout spine at each pole.

Zygospore unknown.

Length without spines 32–42 μ; breadth without spines 30–40 μ; length of spines 18–27 μ; breadth of isthmus 7·5–9·6 μ; thickness 16–20 μ.

Scotland.—Rhiconich, Sutherland! Harris, Outer Hebrides!

Geogr. Distribution.—Germany. Poland. Lappmark in Norway (form).

A. Bulnheimii is a very rare Desmid characterized by the rectangular semicells and the closed linear sinus.

Var. **subincus** *var. nov.* (Pl. CXVI, fig. 3.)

A. Incus "forma apicibus constanter convexis" West, Alg. W. Ireland, 1892, p. 168.
A. Incus var. *validus* forma *minor* W. & G. S. West, Alg. N. Ireland, 1902, p. 58, t. 2, f. 15.

A somewhat smaller variety with the basal angles of the semicells rounded to such a degree that the semicells are almost obversely semicircular.

Length without spines 23–26 μ, with spines 51–54 μ; breadth without spines 25–28 μ, with spines 45–54 μ; breadth of isthmus 6·5–8 μ.

Wales.—Capel Curig and Llyn-y-cwm-ffynon, Carnarvonshire!

Scotland.—Rhiconich, Sutherland; Lewis and Harris, Outer Hebrides!

Ireland.—Near Glenties and Lough Anna, Donegal! Ballynahinch and near Roundstone, Galway! Glengarriff, Cork!

We had for some time erroneously regarded this Desmid as a form of *Arthrodesmus Incus*, as its proper place in a systematic scheme appears to be with *A. Bulnheimii*. No form of *A. Incus* ever possesses a closed sinus with a dilated extremity, and we consider that this one character is alone sufficient to relegate it to *A. Bulnheimii*.

A. Bulnheimii var. *subincus* is a western type of Desmid, and in parts of Lewis, Harris, and the west of Ireland it is sometimes very abundant.

8. **Arthrodesmus convergens** Ehrenb.

(Pl. CXVI, figs. 4–13.)

Arthrodesmus convergens Ehrenb. Infus. 1838, p. 152, t. 10, f. 18; Hass. Brit. Freshw. Alg. 1845, p. 357, t. 85, f. 9; Ralfs, Brit. Desm. 1848, p. 118, t. 20, f. 3; Kütz. Spec. Alg. 1849, p. 176; Arch. in Pritch. Infus. 1861, p. 737; Lund. Desm. Suec. 1871, p. 54; Kirchn. Alg. Schles. 1878, p. 156; Wolle, Desm. U. S. 1884, p. 95, t. 23, f. 19–21; Cooke, Brit. Desm. 1887, p. 136, t. 47, f. 1; Hansg. Prodr. Algenfl. Böhm. 1888, p. 203, f. 117, and p. 251; Nordst. Freshw. Alg. N. Zeal. 1888, p. 45; De Toni, Syll. Alg. 1889, p. 1058; West, Alg. N. Wales, 1890, p. 292; Heimerl, Desm. alp. 1891, p. 603; West, Alg. W. Ireland, 1892, p. 169; Alg. Engl. Lake Distr. 1892, p. 730; Lütkem. Desm. Attersees, 1893, p. 559; Roy & Biss. Scott. Desm. 1894, p. 40; W. & G. S. West, Some N. Amer. Desm. 1896, p. 254, t. 16, fig. 3; Nordst. Index Desmid. 1896, p. 81; W. & G. S. West, Alg. S. England, 1897, p. 497; G. S. West, Variation Desm. 1899, p. 397, 398 and fig. xylogr. 4; Lütkem. Desm. Millstättersees, 1900, p. 70; W. & G. S. West, Alga-fl. Yorks. 1901, p. 108; Alg. N. Ireland, 1902, p. 58; Hirn, Desm. Finland, 1903. p. 5; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 528; Borge, Alg. erst. Regnell. Exped., II. Desmid. 1903, p. 103; Larsen, Freshw. Alg. E. Greenland, 1904, p. 81; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 23; Cushman in Rhodora, vii, 1905,

p. 260; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Borge, Beiträge, Alg. Schweden, 1906, p. 49; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181; Phytoplankton Engl. Lake Distr. 1909, p. 138; Hustedt, Desm. et Bacill. aus Tirol, 1911, p. 336.

Staurastrum convergens Menegh. Synops. Desm. 1840, p. 228; Ralfs in Ann. Mag. Nat. Hist. xv, 1845, p. 158, t. 12, f. 1; Racib. Desm. Krakow, 1884, p. 16 (sep.), t. 1, f. 8.

Scenodesmus convergens Kütz. in Linnæa, xvii, 1843, p. 74.

Euastrum convergens Kütz. Phycol. germ. 1845, p. 136.

Euastrum (*Tetracanthium*) *convergens* Näg. Gatt. einz. Alg. 1849, p. 114, t. 7, f. C 1.

Cosmarium convergens De Bary, Conj. 1858, p. 72.

Didymidium (*Staurastrum*) *convergens* *A. ellipticum* Reinsch, Algenfl. Frank. 1867, p. 154.

Staurastrum convergens α armigera Jacobs. Desm. Danem. 1876, p. 203 [forma *inflata* et forma *attenuata*].

Xanthidium convergens Delp. Desm. subalp. 1877, p. 76, t. 14, f. 13–23.

Arthrodesmus convergens α typica, *β curta*, et *γ minor* Turn. Freshw. Alg. E. India, 1893, p. 134, t. 11, f. 32, 41, 42; t. 12, f. 3.

Cells of medium size, about $1\frac{1}{5}$ or $1\frac{1}{6}$ times broader than long (without the spines), very deeply constricted, sinus opening widely outwards from a narrow and sublinear extremity; semicells more or less elliptic, usually with one margin (and generally the dorsal margin) slightly more convex than the other, lateral angles sometimes rounded-conical, each normally furnished with a rather short and slightly incurved spine. Vertical view rather narrowly elliptic, with a short spine at each pole. Cell-wall smooth or delicately punctate. Chloroplasts as a rule axile with a single central pyrenoid in each semicell, but inclined to be variable.

Zygospore globose and smooth.

Length 33–54 μ; breadth without spines 40–64 μ, with spines 50–90 μ; length of spines 5·5–15 μ; breadth of isthmus 10–17 μ; thickness 18–26μ; diam. zygosp. 39–48 μ.

England.—Cumberland! Westmoreland! (*Ralfs*). Lancashire! (*Ralfs*). W., N., and E. Yorks! Cheshire (*Ralfs*). Leicestershire (*Roy*). Bucks! Warwicks! Gloucester (*Ralfs*). Herts (*Hassall*). Surrey! Sussex (*Ralfs*). Kent (*Ralfs*). Hants! (*Roy*). Devon! Cornwall! (*Ralfs*).

Wales.—Capel Curig (common in the plankton of

the lakes) and Llyn Idwal, Carnarvonshire! Llyn Coron, Anglesey!

Scotland.—General! (*Roy & Bissett*). Lewis and Harris, Outer Hebrides! Orkneys! Shetlands! Scarce in the plankton!

Ireland.—Donegal! Armagh! Dublin and Wicklow (*Archer*). Galway! Kerry! Cork!

Geogr. Distribution.—France. Germany. Austria. Hungary. Italy. Norway. Sweden. Denmark. Bornholm. Finland. N. and S. Russia. Greenland. Nova Zembla. Central China. Japan. India. New Zealand. Abyssinia. Central and E. Africa. United States. Brazil. Paraguay.

This most characteristic species exhibits considerable variation in the degree of development of the spines, and the semicells are also slightly variable in form. These points can be noticed by an inspection of figs. 4–12 on Pl. CXVI.

Examples are often found in which the spines of one semicell are normal and those of the other reduced or absent, and by further division of such a plant a specimen may be produced in which the spines are entirely absent (*vide* Pl. CXVI, fig. 10). On the division of this spineless cell, however, the newly-formed semicells may, and usually do, develop typical spines. Thus, a character which may be entirely lost in a few individuals, as a result of repeated vegetative division, is frequently reproduced at its maximum in a succeeding division (Consult Pl. CXVI, fig. 11, and the remarks under *Cosmarium Regnesi* in Vol. III, p. 38).

The production of occasional spineless individuals of this Desmid leads one to the conclusion that *Arthrodesmus convergens* originated in the first instance from a *Cosmarium* of the nature of *C. depressum* (Näg.) Lund. In fact, the resemblance between *A. convergens* and *Cosm. depressum* is so very close that many suggestions have been made as to their specific identity. These suggestions are, however, based upon insufficient knowledge of these Desmids. It must be remembered that the vegetative divisions of *Cosmarium depressum* always produce unarmed cells similar to the parent generation, but that the spineless cells of *A. convergens* are nevertheless truly *A. convergens* with all those inherited characters which will probably result in the production of full-grown typical spines in the new semicells of the next division.

When in the plankton the spines of *A. convergens* are frequently much reduced.

The form recorded as "forma membrana irregulariter punctata" (cf. W. & G. S. West, 'New Brit. Freshw. Alg.' 1894, p. 9) cannot be regarded as a distinct form, as many specimens of this species clearly show a finely punctate cell-wall.

In a variety of this species (var. *incrassatus* Gutw.) which occurs in Austria and in the United States the cell-wall is thickened by two transverse bars of cellulose stretching across the semicell on each side of the apex.

9. **Arthrodesmus subulatus** Kütz.

(Pl. CXVI, fig. 14; Pl. CXVII, fig. 1.)

Arthrodesmus subulatus Kütz. Spec. Alg. 1849, p. 176; Nordst. Desm. Brasil. 1870, p. 232, t. 4. f. 59 [forma major]; Wolle, Desm. U. S. 1884, p. 96, t. 24, f. 11, 12; De Toni, Syll. Alg. 1889, p. 1059; Börges. Desm. Brasil. 1890, p. 43, t. 5, f. 57 [forma major]; Turn. Freshw. Alg. E. India, 1893, p. 133 [forma media and forma minor]; Roy & Biss. Scott. Desm. 1894, p. 41; West, Alg. Madag. 1895, p. 72, t. 9, f. 32, 33; Some N. Amer. Desm. 1896, p. 254; Borge, Alg. erst. Regnell. Exped. II. Desmid. 1903, p. 103; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 528.

A. convergens Ehrenb. var. *subulatus* (Kütz.) Rabenh. Flor. Europ. Alg. III, 1868, p. 227.

Cells of medium size, about as long as broad (without the spines), deeply constricted, sinus widely open from a more or less subacuminate apex; semicells elliptic-obsemicircular, ventral margin much more convex than the dorsal margin (almost semicircular), lateral angles somewhat rounded, each furnished with a long, stout, straight, and horizontally disposed spine. Vertical view elliptic, each pole furnished with a long straight spine. Cell-wall finely punctate.

Zygospore globose and smooth.

Length 28·4–50 μ; breadth without spines 27–54 μ, with spines 52–100 μ; breadth of isthmus 7–13·5 μ; thickness 15–22 μ; diam. zygosp. 30–36 μ.

Scotland.—Slewdrum, Cambus O'May, and Glen Clunie, Aberdeen (*Roy & Bissett*).

Ireland.—Dublin and Wicklow (*Archer*).

Geogr. Distribution.—India. Madagascar. Abyssinia. United States. Brazil. Paraguay.

Arthrodesmus subulatus is much more frequent in tropical latitudes than in temperate countries. In its typical form it is easily distinguished from *A. convergens* by the shape of its semicells and the long, horizontally-placed spines.

Forma **americana** (Turn.) W. & G. S. West. (Pl. CXVII, figs. 4, 5.)

A. Incus var. *americanus* Turn. New and Rare Desm. 1885, p. 937, t. 16, f. 17; De Toni, Syll. Alg. 1889, p. 1057.
A. triangularis var. *americanus* (Turn.) West, Alg. W. Ireland, 1892, p. 169.
A. elegans West, Alg. W. Ireland, 1892, p. 169, t. 22, f. 7 [gelatinous processes described as "spinis brevibus delicatis truncato-bifurcatis."]
A. subulatus forma *media* Turn. Freshw. Alg. E. India, 1893, p. 133, t. 11, f. 36, 37; t. 12, f. 4.

Differs from the type only in the long spines being slightly convergent, and in the semicells being a little less turgid (in outline rather more triangular).

Length 26–32 μ; breadth without spines 22·5–30 μ, with spines 62–65 μ; length of spines 16–22 μ; breadth of isthmus 7–10 μ; thickness 11–14 μ.

Ireland.—Lakes between Clifden and Roundstone, near Recess, and Ballynahinch, Galway!

Geogr. Distribution.—India. United States.

When *A. elegans* was described from Ballynahinch it was not realized that the short emarginate "spines" were only tough mucilaginous processes which had been secreted through pores in the cell-wall. Similar "spines" or "processes" are frequently met with in this genus (consult Pl. CXIII, fig. 15, and Pl. CXIV, fig. 5 *c*) and they often become quite hard and resistant, although they consist only of the more gelatinous pectose constituents of the cell-wall. Mucous projections (from the pores in the cell-wall) of a precisely similar nature have been described and figured by Lütkemüller in *A. octocornis* (consult Lütkem. 'Zellmembr. Desmid.' 1902, p. 412, t. 18, f. 17).

Var. **subæqualis** *var. nov.* (Pl. CXVII, figs. 2, 3.)

A subulatus as recorded by W. & G. S. West, Alg. N. Ireland, 1902, p. 58; Scott. Freshw. Plankton, I, 1903, p. 528.

Cells proportionately wider (without the spines); semicells more narrowly elliptical with a less con-

spicuous difference in convexity between the ventral and dorsal margins; spines shorter and more slender.

Length 31–38 μ; breadth without spines 31–42 μ, with spines 52–65 μ; long. spin. 10·5–11·5 μ; breadth of isthmus 8–12 μ; crass. 16–19·5 μ.

Scotland.—Plankton of Loch Nan Eun, N. Uist, Outer Hebrides!

Ireland.—Lough Gartan, Donegal!

10. **Arthrodesmus octocornis** Ehrenb.

(Pl. CXVII, figs. 6–10.)

Arthrodesmus octocornis Ehrenb. Infus. 1838, p. 152; Hass. Brit. Freshw. Alg. 1845, p. 357, t. 85, f. 11; Arch. in Pritch. Infus. 1861, p. 736; Rabenh. Flor. Europ. Alg. III, 1868, p. 225; Lund. Desm. Suec. 1871, p. 55; Kirchn. Alg. Schles. 1878, p. 156; Wolle, Desm. U. S. 1884, p. 97, t. 24, f. 22; Cooke, Brit. Desm. 1887, p. 134, t. 47, f. 2; De Toni, Syll. Alg. 1889, p. 1063; West, Alg. N. Wales, 1890, p. 291; Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 64; West, Alg. W. Ireland, 1892, p. 167; Alg. Engl. Lake Distr. 1892, p. 730; Roy & Biss. Scott. Desm. 1894, p. 41; Nordst. Index Desmid. 1896, p. 187; W. & G. S. West, Alg. S. England, 1897, p. 496, t. 6, f. 16; Schmidle Lappmark Süsswasseralgen, 1898, p. 42; Lütkem. Desm. Millstättersees, 1900, p. 71; W. & G. S. West, Alga-fl. Yorks. 1901, p. 109; Börg. Freshw. Alg. Færoës, 1901, p. 229; W. & G. S. West, Alg. N. Ireland, 1902, p. 57; Lütkem. Zellmembr. Desmid. 1902, t. 18, f. 17; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 528; Larsen, Freshw. Alg. E. Greenland, 1904, p. 81; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 485; Borge, Beiträge Alg. Schweden, 1906, p. 49; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 325; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181; Hustedt, Desm. et Bacill. aus Tirol, 1911, p. 336, f. 25.

Micrasterias octocornis Menegh. Synops. Desm. 1840, p. 216.

Staurastrum ? octocorne Ralfs in Ann. Mag. Nat. Hist. 1845, xv, p. 159, t. 12, f. 3.

Euastrum octocorne Kütz. Phycol. germ. 1845, p. 134.

Xanthidium ? octocorne (Ehrenb.) Ralfs, Brit. Desm. 1848, p. 116, t. 20, f. 2 *a–e*; Archer in Q. J. Micr. Sci. 1869, p. 423; Gay, Monogr. loc. Conj. 1884, p. 77; Hirn. Desm. Finland, 1903, p. 24.

Euastrum octacanthum Perty in Mittheil. d. naturforsch. Gesellsch. in Bern, 1849, p. 174.

Didymidium (*Xanthidium*) *octocorne* Reinsch, Algenfl. Frank. 1867, p. 127.

Xanthidium octocorne forma *minor* Jacobs. Desm. Danem. 1876, p. 211.

Arthrodesmus Lapczynskii Gutw. Nonn. alg. nov. 1896, p. 57, t. 7, f. 68.

Cells small, about $1\frac{1}{4}$ times longer than broad (without the spines), deeply constricted, sinus a wide, almost semicircular excavation; semicells tranversely trapeziform-rectangular, sides and apex concave, angles slightly rounded and each furnished with one fairly

long straight spine. Vertical view elliptic, with one straight spine showing at each rounded pole.

Zygospore globose or subglobose, furnished with a few simple straight spines, about 8 of which show at the periphery; wall of spore with a broad and slightly projecting thickening at the base of each spine.

Length without spines 17–27 μ, with spines 30–42 μ; breadth without spines 14·3–19 μ, with spines 28–35·5 μ; breadth of isthmus 4·2–7·6 μ; thickness 6·5–9 μ; diam. zygosp. without spines 15 μ, with spines 28 μ.

England.—Cumberland! Westmoreland! (*Ralfs*; *Bissett*). W. and N. Yorks! Burnham Beeches, Bucks! Gloucester (*Ralfs*). Surrey! (*Ralfs*); zygospores from Puttenham Common! Sussex (*Ralfs*). Hants! (*Ralfs*). Devon! Cornwall! (*Ralfs*).

Wales.—Llyn Bodgynwydd, Capel Curig (*Cooke & Wills*), Llyn Ogwen, Llyn Idwal, Llyn Bochlwyd, Glyder Fach (at 2200 ft.), Llyn-y-cwm-ffynon, Snowdon, and Moel Siabod, Carnarvonshire!

Scotland.—General!; zygospores from Aberdeen, Kincardine, and Perth (*Roy & Bissett*). Outer Hebrides! Scarce in the plankton!

Ireland.—Donegal! Londonderry! Dublin and Wicklow (*Archer*). Galway! Mayo! Kerry! Cork!

Geogr. Distribution.—France. Germany. Poland. Austria and Galicia. Italy. Norway. Sweden. Denmark. Bornholm. Finland. N. Russia. Faeroes. Iceland. Greenland. Mongolia. Japan. Burma. Ceylon. Australia. United States.

A. octocornis is a very characteristic species with a wide distribution. It scarcely needs comparison with any other species, and in the British Islands it exhibits little variation. The "β *major* Ralfs" has been transferred to *Xanthidium Smithii*, a Desmid to which we think it more rightly belongs (consult page 62).

A trigonal variety (var. *trigonum*) was described by Boldt from Greenland in 1888, and has since been found in West Greenland by Larsen.

Lütkemüller ('Desm. Millstättersees,' 1900, p. 13) has given

clear proof that *A. Lapczynskii* Gutw. is merely typical *A. octocornis*, Gutwinski having fallen into the error so repeatedly made in dealing with Desmids of regarding certain of the mucous rods connected with the pores in the cell-wall as an armature of small spines.

Messrs. Roy and Bissett have recorded from Scotland (from a pool on Culblean, beside the old road from Tarland to Ballater, Aberdeen) the Desmid described by Jacobsen ('Desm. Danem.' 1876, p. 211, t. 8, f. 28) as *Xanthidium octocorne* forma IMPAR. We have not seen this Desmid and are very doubtful concerning its inclusion under *Arthrodesmus octocornis*, as it seems to agree more closely with forms of *Xanthidium Smithii*. Jacobsen's description and figure are insufficient to determine this point. The lower angles of the semicells possess one long spine and the upper angles two long spines. We give a copy of Jacobsen's figure (Pl. CXVII, fig. 21).

11. **Arthrodesmus bifidus** Bréb.

(Pl. CXVII, figs. 11–13.)

Arthrodesmus bifidus Bréb. Liste Desm. 1856, p. 135, t. 1, f. 19; Arch. in Pritch. Infus. 1861, p. 736; Rabenh. Flor. Europ. Alg. III, 1868, p. 226; Lund. Desm. Suec. 1871, p. 55; Boldt, Sibir. Chlorophy. 1885, p. 109; Cooke, Brit. Desm. 1887, p. 137, t. 48, f. 2 [figures erroneous]; De Toni, Syll. Alg. 1889, p. 1064; Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 64, t. 3, f. 8; Roy & Biss. Scott. Desm. 1894, p. 40; Nordst. Index Desmid. 1896, p. 59; W. & G. S. West, Alg. S. England, 1897, p. 496; Some Desm. U. S. 1898, p. 319; Lütkem. Desm. Millstättersees, 1900, p. 12; W. & G. S. West, Alg. N. Ireland, 1902, p. 57; Larsen, Ferskvandsalger Vest-Grönl. 1907, p. 324.

Cells minute, about as long as broad, deeply constricted, sinus open, subrectangular, with a minute acuminate extremity; semicells elliptic-lunate with the angles upwardly divergent, apex slightly concave, each lateral angle widely emarginate-bifid. Vertical view narrowly elliptic, with a minute spine at each rounded pole. Cell-wall smooth. Chloroplasts axile, one in each semicell, with a central pyrenoid.

Zygospore unknown.

Length (including the minutely spinate angles) 10–14 μ; breadth 11–15·5 μ; breadth of isthmus 3–5·6 μ; thickness 5–6·5 μ.

ENGLAND.—Burnham Beeches, Bucks! Puttenham

and Thursley Commons, Surrey! Roughter Moor, Cornwall!

Scotland.—Ross, Inverness, Aberdeen!, Kincardine, Perth!, Argyle (*Roy & Bissett*). Sutherland! Lewis, Outer Hebrides!

Ireland.—Near Glenties and Lough Anna, Donegal! Dublin and Wicklow (*Archer*). Ballynahinch, Galway!

Geogr. Distribution.—France. Germany. Switzerland. Austria and Galicia. Sweden. Bornholm. Poland. Greenland. Japan. Azores. United States.

This minute species is rather rare and liable to be overlooked. Its characters are most distinctive, and it cannot easily be confused with any other species of the genus. Lundell gives measurements of Swedish specimens up to 18 μ in length and breadth.

Var. **truncatus** West. (Pl. CXVII, fig. 14.)

A. bifidus Bréb. var. *truncatus* West, Alg. N. Yorks. 1889, p. 293, t. 291, f. 9; Alg. W. Ireland, 1892, p. 169; Alg. Engl. Lake Distr. 1892, p. 730; Alg. S. England, 1897, p. 496; Alga-fl. Yorks. 1901, p. 109; Alg. N. Ireland, 1902, p. 57.

Semicells subhexagonal, sides and apex straight; "angles" not emarginate but truncate, thus making two angles (lateral and apical) on each side of the semicell, each angle being furnished with a minute spine.

Length (including minute spines) 10–15·5 μ; breadth 10–14·4 μ; breadth of isthmus 4·5–5·7 μ.

England.—Bowness and Helvellyn, Westmoreland! Strensall and Pilmoor, N. Yorks! Thursley Common, Surrey! Keston Common, Kent!

Wales.—Moel Siabod, Carnarvonshire!

Ireland.—Near Glenties, Donegal! Ballynahinch, Lough Derryclare, and in small lakes between Clifden and Roundstone, Galway!

Although distinctly rare, we have seen this variety oftener than the type, from which it differs most markedly in the angularity of its semicells.

One form of it was observed from Bowness, Westmoreland, in which the semicells were entirely destitute of spines.

This curious form, unmistakable in its outline, we have named forma SUCCISA W. & G. S. West ('New Brit. Freshw. Alg.' 1894, p. 9, t. 2, f. 52); length 12·5 μ; breadth 11·5 μ; breadth of isthmus 3 μ; thickness 6 μ. (Pl. CXVII, fig. 15).

Var. **latidivergens** West. (Pl. CXVII, fig. 16.)

A. bifidus var. *latodivergens* West, Alg. W. Ireland, 1892, p. 169, t. 22, f. 8.

Semicells with rather larger spines at the emarginate angles, the two spines at each lateral angle being placed exactly at right angles.

Length with spines 18 μ; breadth with spines 18 μ; thickness 6·5 μ.

IRELAND.—Ballynahinch, Galway!

12. **Arthrodesmus trispinatus** W. & G. S. West. (Pl. CXVII, fig. 17.)

Arthrodesmus trispinatus W. & G. S. West, Alg. N. Ireland, 1902, p. 57, t. 2, f. 16; Gutw. Flor. Alg. Mont. Tatr. 1909, p. 466, t. 8, f. 40 [figures very poor].

Cells minute, about as long as broad (without spines), moderately constricted, sinus widely open and rounded; semicells transversely elliptic-oblong, with a broadly concave apex, sides with three equal undulations (three crests and two hollows) each furnished with a short, stout spine, spines divergent. Vertical view elliptic, showing the superposed spines at the poles. Cell-wall smooth.

Zygospore unknown.

Length without spines 11·5 μ, with spines 17 μ; breadth without spines 11 μ, with spines 17 μ; breadth of isthmus 6·2 μ; thickness 7·3 μ; length of spines 3–3·5 μ.

IRELAND.—Lough Gartan, Donegal!

Geogr. Distribution.—Galicia in Austria.

This plant is at once distinguished from all other species of the genus by its small size and by the three spines on the lateral margins of each semicell. It is perhaps nearest to *Arthrodesmus ineptus* (Turn.) W. & G. S. West (= *Xanthidium ineptum* Turn. 'Freshw. Alg. E. India,' 1893, p. 101,

t. 12, f. 21), an Indian species with irregularly disposed spines and cells of a different shape.

No living cells of this plant have yet been seen, and the exact nature of the chloroplasts has not been determined. We have suggested, therefore ('Alg. N. Ireland,' 1902, p. 58), that it may be one of the Protococcales belonging to the genus *Tetraëdron*. If such were the case then "*A. trispinatus*" would to some extent resemble a *Tetraëdron* which has been described on two separate occasions as one of the Desmidiaceæ; first by Wille ('Ferskv. Alg. Nov. Semlj.' 1879, p. 62, t. 13, f. 70) as "*Sphærozosma excavatum* Ralfs var. *Novæ Semliæ* Wille," and secondly by Schmidle ('Beitr. alp. Alg.' 1895, p. 350, t. 15, f. 9) as "*Xanthidium alpinum*."

13. **Arthrodesmus tenuissimus** Arch.

(Pl. CXVII, figs. 18, 19.)

Arthrodesmus tenuissimus Arch. Palmoglœa and descrip. Mesot. 1864, p. 68 (sep. 28), t. 1, f. 50–55; Rabenh. Flor. Europ. Alg. III, 1868, p. 226; Cooke, Brit. Desm. 1887, p. 137, t. 47, f. 3 [figures inaccurate]; Anderss. Sverig. Chlor. 1890, p. 13; Schmidle, Beitr. alp. Alg. 1896, p. 20; Nordst. Index Desmid. 1896, p. 251; W. & G. S. West, Alg. N. Ireland, 1902, p. 59; Lütkem. Desm. Böhm. 1910, p. 497.

Xanthidium tenuissimum (Arch.) Turn. Freshw. Alg. E. India, 1893, p. 137.

Cells minute, a little broader than long (without the minute spines), fairly deeply constricted, sinus widely open, almost rectangular; with a subacute apex; semicells subhexagonal, sides slightly concave (almost straight), apex truncate, straight or slightly concave, lateral angles each with a small, short, horizontally-placed spine, apical angles each furnished with a minute spine or mucro which is not easily seen owing to its direction. Side view of semicell subcircular-depressed, with a minute divergent mucro on each side of the apex. Vertical view broadly fusiform-elliptic, poles acutely cuspidate, with a minute spine on each side near the poles. Cell-wall smooth. Chloroplasts axile, with a central pyrenoid in each semicell.

Zygospore unknown.

Length 8–10 μ; breadth without spines 11–11·5 μ,

with spines 12·5–13·6 μ; breadth of isthmus 5·9–6 μ; thickness 5–5·5 μ.

England.—Helvellyn, Westmoreland!

Wales.—Llyn Teyrn on Snowdon, Carnarvonshire!

Scotland.—Sutherland!, Ross, Aberdeen, Forfar!, Perth (*Roy & Bissett*). Lewis and Harris, Outer Hebrides!

Ireland.—Lough Fea, Londonderry! Featherbed Bog, Dublin Mountains (*Archer*). Ballynahinch, Galway!

Geogr. Distribution.—France. Germany. Galicia and Bohemia in Austria. Arctic Norway. Sweden.

This minute species is unlike any other in the genus. It is very rare, but when it does occur it is often in quantity and generally amongst submerged *Sphagnum*.

It is, perhaps, nearest to *Xanthidium concinnum* Arch., but the semicells are of a somewhat different shape, the spines on the lateral angles are much longer, and there is no central papilla. The minute, paired apical spines do not occur in any other species of *Arthrodesmus*.

Forma **longispina** *f. nov.* (Pl. CXVII, fig. 20.)

A. tenuissimus Arch. as figured by West, Alg. N. Wales, 1890, t. 5, f. 10 [figure very poor and inaccurate as to detail]; West, Alg. W. Ireland, 1902, p. 170, t. 22, f. 9.

Lateral angles of semicells with much longer, horizontally disposed spines.

Length 8–12·5 μ; breadth without spines 9–12·5 μ; with spines 27–31 μ; lat. isthm. 4–5 μ; thickness 5·5–6 μ.

Wales.—Capel Curig, Carnarvonshire!

Ireland.—Ballynahinch and Lough Aunierin, Galway!

Under this form we call attention to the Desmid described by Raciborski as *Arthrodesmus hexagonus* var. *tumida* ('Desm. Tapakoomas.,' 1895, p. 33, t. 4, f. 13) from British Guiana. It appears to differ only in the central protuberance, and is therefore one of those forms which connect the genera *Arthrodesmus* and *Staurastrum*.

Genus 18. **STAURASTRUM** Meyen, 1829; em. Ralfs.

Meyen in Nova acta Acad. Cæsar. Leop. Carol. Nat. cur. t. 14, 1828 (1829). [Description very imperfect.]
Ehrenb. Infus. 1838, p. 142.
Kütz. Phyc. gener. 1843, p. 163.
Ralfs in Ann. Mag. Nat. Hist. xv, 1845, p. 149.
Ralfs, Brit. Desm. 1848, p. 119.
Arch. in Pritch. Infus. 1861, pp. 720, 737.
Rabenh. Flor. Europ. Alg. III, 1868, p. 196.
Lund. Desm. Suec. 1871, p. 7.
Delp. Desm. subalp. 1873, p. 38.
Kirchn. Alg. Schles. 1878, p. 163.
Wolle, Desm. U. S. 1884, p. 119.
Cooke, Brit. Desm. 1887, p. 138.
Hansg. Prodr. Algenfl. Böhm. 1888, p. 210.
De Toni, Syll. Alg. 1889, p. 1136.
Turner, Freshw. Alg. E. India, 1893, p. 132.
G. S. West, Treatise Brit. Freshw. Algæ, 1904, p. 171.
Wille in Engler & Prantl, Natürlich. Pflanzenfam. 1909, p. 9.
Didymocladon Ralfs, Brit. Desm. 1848, p. 144; Delp. Desm. subalp. 1877, p. 78 (sep. p. 174).
Pleurenterium (Lund.) Wille in Engler & Prantl, Natürlich. Pflanzenfam. 1890, p. 11 [= Subgen. *Pleurenterium* Lund. Desm. Suec. 1871, p. 72].
Temperea Bougon in Le Micrographe préparateur, iv, 1896, p. 210.

Cells of very variable size, generally longer than broad (excluding spines or processes), *usually with a radial symmetry;* median constriction variable in depth; semicells most variable in outline, subcircular, elliptic, subtriangular, campanulate, trapeziform, etc., *with the angles frequently produced into hollow processes* of variable length; *vertical view* 3–5 (*or even up to* 11) *-angular or -radiate* (rarely compressed). Cell-wall smooth, punctate, scrobiculate, or granulate, or clothed with spines of various kinds; sometimes furnished with flattened, emarginate, or spiny verrucæ. Chloroplasts generally axile, one in each semicell, consisting of a central mass containing one pyrenoid from which lobes radiate into the angles or processes; in a few species sometimes parietal or partially so (often most irregular) and sometimes axile, and containing several pyrenoids.

Zygospores globose or angular, rarely winged or furnished with blunt warts, commonly clothed with long spines, which are simple or furcate at their

extremities, and each often situated at the apex of a mamillate or obtusely conical protuberance.

The genus *Staurastrum* is primarily distinguished by the radial symmetry of the cells as seen in vertical view. It embraces species of more varied character than any other genus of Desmids.

Through some of the smooth species, and especially through *St. tortum*, *St. cosmarioides*, and *St. Clepsydra* var. *sibiricum*, the genus *Staurastrum* is closely related to certain species of *Cosmarium*, and it is highly probable that most of the species of *Staurastrum* were evolved along various lines from the genus *Cosmarium*. Specialization has been carried to a much greater extent than in the latter genus, and the development of long, hollow processes at the angles of the semicells is a character which is practically confined to the genus *Staurastrum*.

All kinds of spiny forms occur in the genus, from those in which a single spine is present at each angle to those in which the whole surface of the cell is covered with spines. All gradations occur from smooth to granulate species, from granulate to asperulate and minutely-spined forms, and from these to coarsely-spined forms.

All attempts to split up this genus on natural principles have entirely failed. The relationships of the numerous species are too complex and close, so that only arbitrary lines of demarcation can be drawn. Even the genus proposed by Ralfs as *Didymocladon* completely breaks down on considering *all* the known species with accessory processes, both smooth and rough forms. *St. furcigerum* var. *reductum* is almost sufficient in itself to show how unnatural such a genus would be, and the various forms of *St. leptacanthum*, *St. Tohopekaligense*, and others, clearly show how impossible it would be to define the limits of such a genus.

On the whole, it would seem most unwise to split up the large genus *Staurastrum*, but, as in the case of the still larger genus *Cosmarium*, it is more in accordance with our knowledge of the genus to group the species into such sections as will most clearly indicate their probable affinities.

The subgenus *Pleurenterium* founded by Lundell in 1871, and raised to generic rank by Wille in 1890, is just as untenable as *Pleurotæniopsis* amongst the Cosmaria. It was founded to include those species of *Staurastrum* in which the chloroplasts were parietal, and is in consequence one of the most unnatural groups which could possibly be suggested. It would include a few scattered species, having no relation-

ship with each other, in which the parietal disposition of chloroplasts had been independently acquired. Moreover, this so-called parietal disposition of chloroplasts is a matter for further investigation. In most cases careful examination shows them not to be truly parietal, but of an irregular character, and they may be axile in one semicell and parietal, or partially so, in the other. One of the principal species included by Lundell in his subgenus *Pleurenterium* was *St. grande* Bulnh., but the careful investigations of Lütkemüller show that in *most* individuals of this species the chloroplasts are axile. Also in *St. Brasiliense* var. *Lundellii*, another Desmid placed by Lundell in *Pleurenterium*, the chloroplasts are invariably axile.

As mentioned above, there is one feature possessed by a considerable percentage of the species of *Staurastrum* which does not occur in any other genus of Desmids,* namely, the production of the angles of the semicells into hollow processes. We have, therefore, regarded this character as of fundamental importance, and used it as a basis for the primary division of the genus into two large groups of species. In each division we have arranged the species under several fairly well-defined sections.

The outline of the scheme is as follows :—

Division I. Angles of semicells not produced into processes.

a. Cells with only a slight constriction and a very small sinus, semicells subcylindrical in the basal part and angular at the apex.

Section A. Cells subcylindrical, granulate or verrucose.
4 *species.*

Section B. Cells subcylindrical, smooth.
1 *species.*

b. Cells with a well-marked constriction and a deep sinus, semicells 3–6-angled, or rarely compressed.

Section C. Cells smooth or punctate, without spines, verrucæ, or granules.
21 *species.*

Section D. Cells furnished with small granules, regularly or irregularly disposed, often covering the whole cell-wall or sometimes more or less restricted to the angles.
15 *species.*

* The only other known processes of this nature are those on the lobes of a few species of *Micrasterias*, such as *M. americana*, *M. Mahabuleshwarensis*, *M. anomala*, *M. muricata*, *M. Nordstedtiana*, etc., and those at the apices of the elongated semicells of *Triploceras*.

Section E. Cells furnished with spines at the angles only, each angle provided with single or binate spines, rarely with three or four.

About 29 *species.*

Section F. Cells with numerous spines, either clothing the whole surface of the cell-wall or more or less restricted to the vicinity of the angles.

About 21 *species.*

Section G. Cells with verrucæ, which are emarginate or very much reduced and 2–3-spinate.

About 8 *species.*

Division II. Angles of semicells produced into processes.

a. Processes arising exclusively from the angles of the semicells, and therefore all arising in the same horizontal plane.

Section H. Processes smooth (although usually emarginate, furcate, or spinate at the extremity).

About 9 *species.*

Section I. Processes rough, denticulate or spinate along their whole length.

About 46 *species.*

b. Processes not arising exclusively from the angles of the semicells, and therefore with their points of origin in more than one horizontal plane.

Section J. Semicells with accessory processes, most commonly of dorsal origin.

About 15 *species.*

The ten sections just enumerated not only meet all the requirements of the British species, but of all the known species of *Staurastrum*. We have indicated, in most cases provisionally, the number of British species of each section.

In most of these sections there are species of an intermediate character of which the exact systematic position is somewhat doubtful. To the best of our judgment we have placed these species alongside their nearest relatives.

For greater convenience, a synopsis of the British species contained in any section is given immediately in front of that section.

* * *

Section A.

Cells subcylindrical, granulate or verrucose.

* Semicells uniformly granulate. 1. *St. Meriani.*

** Semicells granulate in the upper part (or more rarely with very short minute spines), with a basal ring of verrucæ.

† Three apical lobes of semicells spreading horizontally. 2. *St. capitulum.*

†† Three apical lobes of semicells upwardly divergent. 3. *St. pileolatum.*

*** Semicells verrucose both in the upper part and at the base. 4. *St. rhabdophorum.*

1. **Staurastrum Meriani** Reinsch.

(Pl. CXVIII, figs. 4–6.)

Staurastrum Meriani Reinsch, Spec. Gen. Alg. 1867, p. 125, t. 23 D I, fig. 1–11; Nordst. Norges Desm. 1873, p. 29; Wolle, Desm. U. S., 1884, p. 132, t. 46, f. 17–19; Nordst. Desmid. Grönl. 1885, p. 10; Cooke, Brit. Desm. 1887, p. 161, t. 55, f. 2; West, Desm. Mass. 1889, t. 3, f. 22; Alg. N. Yorks. 1889, p. 293; De Toni, Syll. Alg. 1889, p. 1192; West, Alg. N. Wales, 1890, p. 294; Hansg. Prodr. Algenfl. Böhm. ed. germ. II, 1892, p. 259; West, Alg. W. Ireland, 1892, p. 179; Alg. Engl. Lake Distr. 1892, p. 732; Roy & Biss. Scott. Desm. 1893, p. 22 (sep.); Nordst. Index Desm. 1896, p. 169; W. & G. S. West, Alg. S. England, 1897, p. 494; Lütkem. Desm. Millstättersees, 1900, p. 80; W. & G. S. West, Alga-fl. Yorks. 1901, p. 103; Börg. Freshw. Alg. Færoës, 1901, p. 231; W. & G. S. West, Alg. N. Ireland, 1902, p. 51; Larsen, Freshw. Alg. E. Greenland, 1904, p. 98; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 185; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 350.

Didymidium (*Staurastrum*) *Meriani* Reinsch. Algenfl. Frank. 1867, p. 160, t. 12, f. 1.

Calocylindrus cylindricus (Ralfs) Racib. var. *hexagona* Racib. in Spraw. Kom. fizyjogr. Akad. Um. Krakow, xix, 1884, p. 9.

Staurastrum hexagonum Racib. Nonn. Desm. Polon. 1885, p. 85, t. 12, f. 3.

Dysphinctium Ralfsii (Kütz.) Hansg. var. *hexagonum* Schmidle, Alg. Bern. Alp. 1894, p. 92.

Cosmarium pseudoralfsii Migula in Flora von Deutschland, Österreich und der Schweiz. Bd. 5 (Desmidiaceæ in parts 29–36), 1906, p. 423.

Staurastrum Meriani forma *constricta* Teodoresco, Matér. flor. alg. Rouman. 1907, p. 185.

Cells rather small, about twice as long as broad, slightly constricted, sinus a small indentation; semicells trapeziform-rectangular or trapeziform-quadrate,

wider at the apex than at the base, basal angles slightly rounded, sides faintly retuse, apical angles a little dilated and rounded, apex strongly convex and often flattened in the middle. Vertical view 3–6-gonal (commonly tetragonal or pentagonal), angles rounded, sides almost straight. Cell-wall evenly granulate all over; granules for the most part without any definite arrangement, but with distinct indications of ring-like series around the angles.

Zygospore unknown.

Length 36–46 μ; breadth of base of semicells 17–20 μ, of apex 20–26 μ; breadth of isthmus 13–18 μ.

England.—Buttermere, and Blea Tarn in Borrowdale, Cumberland! Ambleside and Blea Tarn (*Bissett*), and Helvellyn!, Westmoreland. Near Cockley Beck, Lancashire! Blubberhouses (*Turner*), Baildon!, Ingleton!, Penyghent!, and Cowgill Wold Moss on Widdale Fell!, W. Yorks. Mickle Fell, N. Yorks! Hartlebury Common, Worcestershire! Tintagel, Cornwall!

Wales.—Glyder Fawr, Snowdon, and near Llyn Padarn, Carnarvonshire!

Scotland.—General, but scarce! (*Roy & Bissett*). Skye! Lewis, Outer Hebrides! Orkneys! Shetlands!

Ireland.—Near Glenties and near Lough Magrath, Donegal! Lough Derryclare, Galway! Carrantuohill, and 8 miles S. of Kenmare, Kerry! Dublin and Wicklow (*Archer*). Westmeath (*Archer*). Slieve Donard, Down (at 2000 feet)!

Geogr. Distribution.—France. Germany. Switzerland. Austria and Galicia. Roumania. Italy. Norway. Faeroes. Greenland. United States.

St. Meriani is a very distinctive upland species. It occurs in alpine and subalpine lakes, tarns, and boggy rills; and is also not uncommonly found amongst mosses and hepatics on the dripping rocks of subalpine ghylls and glens. The form of its semicells, combined with its uniform granulation,

at once distinguishes it from all other species of the genus. The commonest forms are pentagonal in vertical view, although tetragonal forms are by no means infrequent.

A form in which the apex of the semicells is more elevated has been described by Borge from Norway (Finmark) as "forma *rotundata*" (Borge, 'Chlorophy. Norska Finmark.' 1892, p. 7, t. 1, f. 4).

2. **Staurastrum Capitulum** Bréb.

(Pl. CXVIII, figs. 7 and 10.)

Staurastrum Capitulum Bréb. in Ralfs' Brit. Desm. 1848, p. 214, t. 35, f. 25 [figure inaccurate]; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 209; Kirchn. Alg. Schles. 1878, p. 165; De Toni, Syll. Alg. 1889, p. 1191; West, Alg. N. Wales, 1890, p. 294; Borge, Süssw. Chlor. Archang. 1894, p. 37; Nordst. Index Desm. 1896, p. 72.

St. amœnum Hilse in Ber. d. Schles. Gesellsch. 1865 [1866], p. 123; Kirchn. Alg. Schles. 1878, p. 165; Wille Ferskvandsalg, Nov. Semlj. 1879, p. 54; De Toni, Syll. Alg. 1889, p. 1191; Heimerl, Desm. alp. 1891, p. 606; West, Alg. W. Ireland, 1892, p. 179; Alg. Engl. Lake Distr. 1892, p. 732.

St. Capitulum b. *amœnum* Rabenh. Flor. Europ. Alg. III, 1868, p. 209; Cooke, Brit. Desm. 1887, p. 161; W. & G. S. West, Alga-fl. Yorks. 1901, p. 107.

Cells rather small, about $1\frac{1}{2}$–$1\frac{3}{5}$ times as long as broad, slightly constricted, sinus a small acute-angled notch; semicells campanulate from a broad base, which is slightly tumid on each side and 2–4-denticulate (this marginal appearance being caused by a ring of denticulate verrucæ completely encircling the base of the semicell), sides slightly retuse above the base and then upwardly divergent, apex broad and faintly retuse, apical angles generally denticulate with sharp granules arranged in concentric rings; granules diminishing in size and sharpness as they extend towards the basal ring of verrucæ. Vertical view of basal part of semicell circular with a crenate margin; crenæ 10–12, denticulate or emarginate; vertical view of apical part triangular with subacute angles and almost straight sides.

Zygospore unknown.

Length 37–40 μ; breadth of base of semicell 21–22 μ, of apex 26–28 μ; breadth of isthmus 13–14·5 μ.

England.—Scawfell, Cumberland! Easdale and Stickle Tarns, Westmoreland! Old Cote Moor and Cam Fell, W. Yorks! Bog near Widdale Beck, N. Yorks! Dartmoor, Devonshire (*Joshua*).

Wales.—Moel Siabod and Llyn Bochlwyd, Carnarvonshire! Dolgelly, Merioneth!

Ireland.—Kylemore, Galway! Carrantuohill and Lower Lake of Killarney, Kerry!

Geogr. Distribution.—France. Germany. Austria and Galicia. Servia. Italy. Norway. Poland. Greenland. Azores.

With regard to the Desmids described under the names of *St. Capitulum*, *St. amœnum*, and *St. pileolatum*, a few plain statements are necessary. The original descriptions of *St. Capitulum* and *St. pileolatum* are very brief and imperfect, but the *outlines* of the figures are moderately good. *St. amœnum* appears to have been founded upon a misconception of the true nature of *St. Capitulum*—a misconception which we venture to think was due entirely to the failure of the author to realise that the figure given by Ralfs was inaccurate in its detail. This figure was only a copy of one of Brébisson's drawings, and nearly all that author's figures are very inaccurate, the detail being invariably wrong.

We have a wide acquaintance with these forms of *Staurastrum* in the British Islands and in western Europe generally, and have come to the conclusion that it is only possible to recognize two species. These must of necessity be referred to *St. Capitulum* and *St. pileolatum*, the two originally described and so poorly figured by Brébisson in the Appendix to Ralfs' 'British Desmids.' A comparison of a large series of specimens with all the published information on these Desmids convinces us that no other interpretation would be consistent with the known facts.

These two species are distinct only by reason of the direction of the apical angles of the semicell, which in *St. Capitulum* are horizontally spreading whereas in *St. pileolatum* they are upwardly directed.

In addition to what we regard as the type form the following varieties of this species can be distinguished, of which only the first is at present known to occur in the British Islands:—

Var. spetsbergense (Nordst.) Cooke, Brit. Desm. 1887, p. 161, t. 55, f. 3. For description see below.

Var. ITALICUM (Nordst.)—*St. amœnum* var. *italicum* Nordst. Desm. Ital. 1876, p. 43, t. 13, f. 18. Semicells with a convex apex, granules of upper part of semicell all arranged on small flattened warts which are well seen in the vertical view; basal part of semicell triangular, angles granulate and with a small granulate tumour in the middle of each side. Length 31 μ; breadth of base of semicell 20 μ, of apex 28–30 μ; breadth of isthmus 18 μ. Italy.

Var. ACANTHOPHORUM (Nordst.)—*St. amœnum* subsp. *acanthophorum* Nordst. l. c. t. 13, f. 19. Each basal verruca furnished with a pair of sharp spines; granules of upper part of semicells very acute and with a tendency to be arranged on flattened warts. Length 38 μ; breadth of base of semicell 19 μ, of apex 24; breadth of isthmus 14 μ. Italy. Austria (Tyrol and Bohemia).

Var. TUMIDIUSCULUM (Nordst.)—*St. amœnum* var. *tumidiusculum* Nordst. in Bot. Notiser, 1887, p. 158; Freshw. Alg. of N. Zeal. 1888, p. 38, t. 4, f. 13. Apical angles inclined to be verruculose rather than granulate or denticulate; vertical view quadrangular with straight sides and slightly dilated angles. Length 45 μ; breadth of apex (max.) 40 μ; breadth of isthmus 24 μ. New Zealand. We have given a figure of this variety for comparison with var. *spetsbergense* (Pl. CXVIII, fig. 9).

Var. **spetsbergense** (Nordst.) Cooke. (Pl. CXVIII, fig. 8.)

St. Capitulum var. *amœnum* forma *spetsbergensis* Nordst. Desm. Spetsb. 1872, p. 39, t. 7, f. 25 [figures not quite correct according to Nordstedt]; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 348.

St. amœnum forma *spetsbergensis* Nordst. Desm. arct. 1875, p. 36; Boldt. Desm. Grönl. 1888, p. 39; Roy & Biss. Scott. Desm. 1893, p. 178; Borge, Süssw. Chlor. Archang. 1894, p. 37.

St. Capitulum var. *spetsbergense* (Nordst.) Cooke, Brit. Desm. 1887, p. 161, t. 55, f. 3.

With the sharp granules (or denticulations) of the upper angles fewer in number and more irregularly disposed.

Length 34–45 μ; breadth of base of semicell 26–28 μ, of apex 31–33 μ; breadth of isthmus 12–20 μ.

ENGLAND.—Blea Tarn, Westmoreland (*Bissett*).

WALES.—Capel Curig and Pen-y-gwryd, Carnarvonshire (*Roy*).

Scotland.—Sutherland, Ross, Inverness, Aberdeen, Kincardine, Forfar, Perth, Dumbarton, and Bute (*Roy & Bissett*).

Geogr. Distribution.—Spitzbergen. Nova Zembla. N. Russia. Brazil.

We have not seen this variety, and we are inclined to think that Messrs. Roy & Bissett have referred to it all the forms of *St. Capitulum* which came under their notice. It differs so little from typical *St. Capitulum* that it is hardly worth the separation.

3. **Staurastrum pileolatum** Bréb.

(Pl. CXVIII, figs. 11–13.)

Staurastrum pileolatum Bréb. in Ralfs' Brit. Desm. 1848, p. 215, t. 35, f. 22 [figure inaccurate]; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 220; Cooke, Brit. Desm. 1887, p. 160, t. 55, f. 1; Hansg. Prodr. Algenfl. Böhm. 1888, p. 216; De Toni, Syll. Alg. 1889, p. 1191; West, Alg. N. Wales, 1890, p. 294; Roy & Biss. Scott. Desm. 1893, p. 241; Nordst. Index Desm. 1896, p. 200.

St. amœnum Hilse var. *brasiliense* Börg. as recorded by West, Alg. W. Ireland, 1892, p. 179, t. 23, f. 9.

St. pileolatum Bréb. var. *brasiliense* (Börg.) Lütkem. as recorded by W. & G. S. West, Alga-fl. Yorks. 1901, p. 107; Notes Alg. III, 1903, p. 11 (sep.); Freshw. Alg. Orkneys and Shetlands, 1905, p. 28.

Cells rather small, about twice as long as broad, slightly constricted, sinus a small acute-angled notch; semicells rectangular-subcampanulate, base broad and very slightly tumid-emarginate just above the sinus (caused by a ring of emarginate verrucæ or short ridges which completely encircle the base of the semicell), sides slightly retuse near the base, after which they diverge very slightly upwards, apex concave, apical angles rounded-conical and minutely granulate, each with about 5 concentric rings of small granules, those near the basal verrucæ becoming very minute. Vertical view of basal part of semicell circular with a crenate margin; crenæ 18–21, bluntly rounded; vertical view of apical part of semicell triangular (rarely quadrangular) with acutely-rounded angles and very slightly concave sides.

Zygospore globose, furnished with a few short, stout spines, 2–3-fid at the apex.

Length 40–44 μ; breadth of base of semicells 18·5–22 μ, of apex 20–25 μ; breadth of isthmus 14–16·5 μ.

England.—Bog near Widdale Beck, N. Yorks! Scawfell, Cumberland! Bovey Tracey, Devonshire (*Joshua*).

Wales.—Capel Curig, and at 2200 feet on Glyder Fach, Carnarvonshire! Dolgelly, Merioneth!

Scotland.—Ross, Aberdeen, Kincardine, Perth, Argyll; zygospores from Den of Garrol, Kincardine (*Roy & Bissett*). Glen Nevis and Invermoidart, Inverness! Near Lerwick, Shetlands!

Ireland.—Dublin and Wicklow (*Archer*). Ballynahinch!, and Leenane (*Archer*), Galway.

Geogr. Distribution.—France. Germany. Austria (Bohemia). Bulgaria. Brazil.

St. pileolatum is distinguished from *St. Capitulum* by two main features; first, the upwardly directed apical angles of the semicells, resulting in a markedly concave apex, and secondly, the greater number of verrucæ encircling the base of the semicells. The granulation is also a little different, as the granules are never sharp and spine-like in *St. pileolatum*.

The verrucæ at the base of the semicell are variable in character, but the most frequent form possesses longitudinally compressed and slightly emarginate verrucæ, which might almost be described as short emarginate ridges (consult Pl. CXVIII, figs. 11 and 12). Sometimes the verrucæ are not so compressed and are furnished with blunt teeth at their angles, in which case they much resemble those of *St. Capitulum* (consult fig. 13).

Brébisson's figure of this species (in Ralfs' 'Brit. Desm.' 1848, t. 35, f. 22) is very inaccurate as to detail, but the outline and general proportions are not bad. The granulation as depicted at the base of the semicell is an obvious error.

In addition to the type form of *St. pileolatum* there are two others which are sufficiently distinct to merit definite varietal names. These are:—

Var. cristatum Lütkem. For description see below.

Var. brasiliense (Börg.) Lütkem. Desm. Attersees, 1893, p. 567. *St. amœnum* Hilse var. *brasiliense* Börg. Desm. Brasil. 1890, p. 45, t. 4. f. 44. Basal verrucæ of semicells larger and fewer in number (about 13), each surmounted by 5 or 6 minute, irregularly disposed denticulations. Long. 45 μ; lat. 19 μ; lat. isthm. 12 μ. *Hab.* Brazil. We had

recorded this variety from Yorkshire, N. Wales, the Shetlands, and from the west of Ireland, but we have since found that the specimens in all instances were of the typical form.

Var. **cristatum** Lütkem. (Pl. CXVIII, fig. 14.)

St. pileolatum Bréb. var. *cristatum* Lütkem. Desm. Attersees, 1893, p. 566, t. 9, f. 16; Gutw. Flor. Alg. Mont. Tatr. 1909, p. 474.
St. Lewisianum Turn. Desm. Notes, Nov. 1893, p. 345, fig. 8 on p. 344 [figure incorrect].

With the basal arc of granules on the underside of each apical angle transformed into small, longitudinally compressed, emarginate verrucæ.

Length 35·5–41 μ; breadth of base of semicell 20–22 μ, of apex 20–23 μ; breadth of isthmus 15–16 μ.

Wales.—On the Llanberis slopes of Snowdon, Carnarvonshire! (*J. H. Lewis*).

Geogr. Distribution.—Austria and Galicia.

The only important distinction between this variety and the type is the duplication of the granules forming the lowermost series on the underside of the apical angles. These binate granules are situated on very small compressed warts, which form arcs round the bases of the apical angles. Lütkemüller found in his Austrian specimens a large granule immediately under the point of junction of two adjacent arcs, but we have not observed these granules in the Welsh specimens.

We have examined a number of the specimens collected by Mr. J. H. Lewis on the slopes of Snowdon towards Llanberis and have given an illustration of one of them (Pl. CXVIII, fig. 14). These specimens were made the foundation of a distinct species by Turner, under the name of *St. Lewisianum*, but Turner's description and figure are both very inaccurate.

4. **Staurastrum rhabdophorum** Nordst. (Pl. CXVIII, fig. 15.)

Staurastrum rhabdophorum Nordst. Desm. Arctoæ, 1875, p. 36, t. 8, f. 40; Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 54; De Toni, Syll. Alg. 1889, p. 1179; Roy & Biss. Scott. Desm. 1893, p. 242 (sep. p. 24).

Cells rather under medium size, cylindrical, 1½-times as long as broad, very slightly constricted, sinus a small notch, dilated inwardly; semicells subquadrate,

basal angles rectangular, margin at the base crenate-denticulate (which appearance is due to a basal ring of longitudinally compressed denticulate verrucæ), apex truncate-convex, furnished with about 7 emarginate verrucæ at the margin and about 6 denticulate verrucæ within the dorsal margin. Vertical view triangular-subcircular or quadrangular-subcircular, entire margin furnished with emarginate verrucæ, and with a series of verrucæ within the margin.

Zygospore unknown.

Length 47·5 μ; breadth of base of semicells 31·5 μ, of apex 31·5–33·3 μ; breadth of isthmus 25 μ.

Nordstedt mentions the two following forms:

Forma trigona.—Vertical view triangular-circular, with 15 (= 3 × 5) marginal verrucæ, with 9 (= 3 × 3) within the margin, and usually with 18 (= 3 × 6), more rarely with 16 or 17, basal verrucæ.

Forma tetragona.—Vertical view quadrangular-circular, with 20 (= 4 × 5) marginal verrucæ, with 12 (= 4 × 3) within the margin, and usually with 20 (= 4 × 5), more rarely with 19, basal verrucæ.

Scotland.—On the table-land north-west of Canlochan, Aberdeen (or Forfar ?) (*Roy & Bissett*).

Geogr. Distribution.—Spitzbergen. Nova Zembla.

We have not yet seen this characteristic arctic Desmid. It is so distinctive that it scarcely needs comparison with any other species of the genus.

Section B.

Cells subcylindrical, smooth.

5. **Staurastrum minutissimum** Reinsch.

(Pl. CXIX, fig. 2.)

Staurastrum minutissimum Reinsch, Spec. Gen. Alg. 1867, p. 140, t. 23 A II, f. 3–8; ? Rabenh. Flor. Europ. Alg. III, 1868, p. 201; Reinsch, Contrib. Alg. et Fungi, 1875, p. 91, t. 16, f. 3 [forma]; De Toni, Syll. Alg. 1889, p. 1184; Borge, Süsswasseralgen Franz Josefs-Land, 1899, p. 763.

Didymidium (*Staurastrum*) *minutissimum* Reinsch, Algenfl. Frank. 1867, p. 153, t. 13, f. 1.

Cells minute, a little longer than broad, very slightly constricted, sinus very obtuse-angled (about 140°); semicells quadrate-cuneiform, sides almost straight, apex concave, apical angles a little produced and rounded. Vertical view tetragonal or pentagonal (more rarely trigonal), with concave sides and rounded angles. Cell-wall smooth.

Zygospore unknown.

Length 8–12 μ; breadth 7–9 μ; breadth of isthmus 6–7·5 μ.

Geogr. Distribution.—Germany.

The above description and the measurements refer to *St. minutissimum* as described by Reinsch, and fig. 2 on Pl. CXIX is a copy of one of Reinsch's original figures.

So many different forms have been referred to "*Staurastrum minutissimum* Auersw." that it was felt to be an absolute necessity to carefully examine Auerswald's original specimens. Fortunately, these were issued in Rabenh. Alg. Europ. 1863, no. 1428 (c. fig.). All the specimens thus distributed consist of a stout form of *St. inconspicuum* Nordst., and both the description and figure given by Auerswald are erroneous. Therefore, the only '*St. minutissimum*' which can be regarded as a valid species is that described and figured by Reinsch in 1867, and hence Reinsch must remain the authority for this species. Even then the species remains doubtful, as nearly all the published figures since 1867 differ widely from those of Reinsch.

Most of Reinsch's figures represent a minute *Staurastrum* with concave apices, and this we have regarded as the type-form. We suggest the following arrangement of the other known forms of *St. minutissimum* :—

Var. CONVEXUM nob. [= *St. minutissimum* Reinsch, Spec. Gen. Alg. 1867, t. 23 A II, f. 1, 2.] Constriction of cells somewhat deeper; apex of semicells convex. (Pl. CXIX, fig. 3.)

Forma *trigona*. *St. minutissimum* forma *trigona major* et *minor* Wille, Fersky. Alg. Nov. Semlj. 1879, p. 52, t. 13, f. 59, 60; Larsen, Freshw. Alg. E. Greenland, 1904, p. 98. Vertical view triangular, with very slightly concave sides. Length 18–29 μ; breadth 17–29 μ; breadth of isthmus 9–11 μ. (Pl. CXIX, fig. 5.) *Hab.* Greenland. Nova Zembla.

Forma *tetragona*. *St. minutissimum* forma *tetragona*

Nordst. Desm. Arctoæ, 1875, p. 33, t. 8, f. 36. Cells proportionately wider; vertical view tetragonal with slightly concave sides. Length 15 μ; breadth 15–17 μ; breadth of isthmus 13 μ. (Pl. CXIX, fig. 4.) *Hab.* Spitzbergen.

Var. CONSTRICTUM West. Constriction deeper, sinus forming a right angle; apex of semicells straight or slightly concave. See below.

Messrs. Roy and Bissett have recorded "*St. minutissimum* Auersw." from Cairngorm, Inverness; Milton Moor, and Tomachar in Cromar, Aberdeen; and Kerloch, Kincardine. We do not know, however, to which form these records refer.

The only form we have personally observed in the British Islands is the following:—

Var. **constrictum** West. (Pl. CXIX, fig. 6.)

St. minutissimum var. *constrictum* West. Alg. W. Ireland, 1892, p. 172, t. 24, f. 14; Cushman in Rhodora, 1905, p. 263.

Rather larger than the type and more deeply constricted, apex of semicells straight or slightly concave; vertical view triangular, with subconcave sides.

Length 16–24 μ; breadth 17·5–24 μ; breadth of isthmus 9 μ.

IRELAND.—Near Clifden, Galway!

Geogr. Distribution.—United States.

SECTION C.

Cells smooth or punctate, without spines, verrucæ, or granules.

* Angles more or less rounded or furnished with a small solid mucro or mamilla.

† Sinus open and acute-angled (or more rarely obtuse-angled).

‡ Semicells more or less elliptic, angles rounded or acutely rounded.

§ Angles not thickened and without a mucro.

6. *St. muticum.*
7. *St. Bieneanum.*
8. *St. ellipticum.*
9. *St. coarctatum.*
10. *St. grande.*

§§ Angles with a small mucro or a mamilla.

11. *St. tumidum.*
12. *St. conspicuum.*
13. *St. aversum.*
14. *St. brevispinum.*
15. *St. lanceolatum.*

§§§ Angles thickened.

16. *St. pachyrhynchum.*

‡‡ Semicells obversely triangular.

17. *St. Clepsydra.*

‡‡‡ Semicells rhomboidal.

18. *St. inelegans.*
19. *St. angulatum.*

†† Sinus closed and linear.

‡ Semicells widely subpyramidate-trapeziform or subsemi-circular.

20. *St. orbiculare.*
21. *St. suborbiculare.*
22. *St. retusum.*

‡‡ Semicells elongately subpyramidate-inflated.

23. *St. Cosmarioides.*

** Angles distinctly produced into a hollow mamillate lobe.

24. *St. tortum.*
25. *St. subpygmæum.*
26. *St. corniculatum.*

6. **Staurastrum muticum** Bréb.

(Pl. CXVIII, figs. 16–20.)

Binatella mutica Bréb. Alg Falaise, 1835, p. 57, t. 8.
? Staurastrum trilobum Menegh. Conspect. Alg. Eugan. 1837, p. 18 (sep.).
St. muticum Bréb. in Menegh. Synops. Desm. 1840, p. 228; Ralfs, Brit. Desm. 1848, p. 125, t. 21, f. 4, t. 34, f. 13; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 200; Kirchn. Alg. Schles. p. 163; Gay, Monogr. loc. Conj. Montpellier, 1884, p. 64; Wolle, Desm. U. S. 1884, p. 119, t. 39, f. 11, 12 [figures poor]; Cooke, Brit. Desm. 1887, p. 156, t. 51, f. 6; Hansg. Prodr. Algenfl. Böhm. 1888, p. 210; De Toni, Syll. Alg. 1889, p. 1177; West, Alg. N. Wales, 1890, p. 293; Heimerl, Desm. alp. 1891, p. 605; West, Alg. W. Ireland, 1892, p. 176; Alg. Engl. Lake Distr. 1892, p. 731; Lütkem. Desm. Attersees, 1893, p. 563; Roy & Biss. Scott. Desm. 1893, p. 241 (p. 23 sep.); Nordst. Index Desm. 1896, p. 179; W. & G. S. West, Alg. S. England, 1897, p. 494; G. S. West, Variation Desm. 1899, p. 391; W. & G. S. West, Alga-fl. Yorks. 1900, p. 100; Alg. N. Ireland, 1902, p. 49; Freshw. Alg. Ceylon, 1902, p. 178; Borge, Alg. erst Regnell. Exped., II. Desmid. 1903, p. 106; Larsen, Freshw. Alg. E. Greenland, 1904, p. 98; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Comp. Study Plankton Irish Lakes, 1906, p. 86; Borge, Beiträge Alg. Schweden, 1906, p. 43; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 351; G. S. West, Alg. Yan Yean, 1909, pp. 15, 28; W. & G. S. West, Brit. Freshw.

Phytoplankton, etc., 1909, p. 182; Hustedt, Desm. et Bacill. aus Tirol, 1911, p. 337.

St. muticum var. *ellipticum* Wolle, Desm. U. S. 1884, t. 39, f. 13.

St. muticum a. *typicum* Riabin. in Bull. Soc. Imp. Natur. Moscou, 1888, no. 2, p. 329.

St. depressum (Näg.) Turn. forma *aperta* Turn. Freshw. Alg. E. India, 1893, p. 104, t. 13, f. 19.

Cells small, as long as broad or a little longer, deeply constricted, sinus open and acute-angled; semicells usually elliptic, but often elliptic-semicircular or even subreniform. Vertical view triangular or quadrangular, with broadly rounded angles and concave sides. Cell-wall smooth.

Zygospore globose, furnished with stout spines which are bifurcate at the apex [*Ralfs*].

Length 22–43·5 μ; breadth 21–37·5 μ; breadth of isthmus 7·5–12 μ; diam. zygosp. without spines 38 μ; length of spines 9·5–12 μ.

England.—Westmoreland! (*Ralfs*). W., N., and E. Yorks! Essex! Warwick (*Wills*). Surrey! Hants! Devon! (*Bennett*). Cornwall!

Wales.—Bethesda!, Snowdon!, and Capel Curig! (*Cooke & Wills*), Carnarvonshire. Dolgelly, Merioneth (*Ralfs*). Plankton of various Welsh lakes!

Scotland.—Sutherland!, Inverness, Aberdeen, Kincardine, Perth, Stirling, Argyll (*Roy & Bissett*). Orkneys! Shetlands!

Ireland.—Castlebar and Achill Island, Mayo! Lough Guitane, Kerry! Adrigole, Cork! Dublin and Wicklow (*Archer*). Plankton of Lough Neagh!

Geogr. Distribution.—France. Germany. Austria and Galicia. Hungary. Italy. Norway (and Finmark). Sweden. Denmark. Bornholm. Finland. N. and S. Russia. Faeroes. Spitzbergen. Greenland (var.). Siberia. Mongolia. Java. Australia. Central Africa. Azores (var.). Sandwich Islands. United States. Brazil.

St. muticum is a widely distributed species which sometimes occurs in more or less abundance at the margins of pools and lakes. The outward form of the semicells is somewhat variable, and both triangular and quadrangular vertical views are common.

The range of size in this species is considerable, and although it has been customary to specially mention the smaller forms, any line of demarcation is purely arbitrary. The following small form is recorded by many authors, but in some cases it is questionable whether the author who recorded it was aware of the fact that the only basis of separation was "size."

Forma MINOR Rabenh. Flor. Europ. Algar. III, 1868, p. 200; Lund. Desm. Suec. 1871, p. 56; Boldt, Siber. Chlorophy. 1885, p. 110. *Phycastrum depressum* Näg. Gatt. einzell. Alg. 1849, p. 126, t. 8, f. A 1. *St. muticum* var. *minor* Wolle, Desm. U. S. 1884, p. 119, t. 39, f. 14, 15; Hansg. Prodr. Algenfl. Böhm. 1888, p. 255 ["var. *minus*"]; W. & G. S. West, Alg. S. England, 1897, p. 494; Alg. N. Ireland, 1902, p. 49; ? Cushman in Rhodora, v, 1903, p. 224. *St. muticum* var. *depressum* (Näg.) Nordst. in Pointsf. Skandin. Växt. iv, 1880, p. 27; Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 109. *St. depressum* (Näg.) Turn. Freshw. Alg. E. India, 1893, p. 104.

Cells smaller; length 16–21 μ; breadth 15·5–17 μ; breadth of isthmus 4·5–5 μ.

ENGLAND.—New Forest, Hants!

SCOTLAND.—Hoy, Orkneys!

IRELAND.—Near Glenties, Loughs Machugh and Magrath, Donegal!

Geogr. Distribution.—Germany. Austria. Sweden. Siberia. India. United States.

Cushman records "*St. muticum* var. *minor* Wolle" from New England with zygospores. He describes these spores as clothed with numerous acute spines, which is a striking contrast to the zygospore of *St. muticum* described and figured by Ralfs (consult Pl. CXVIII, fig. 20). It leads one to suspect that the zygospores observed by Cushman did not belong to the same species as that described by Ralfs.

7. **Staurastrum Bieneanum** Rabenh.

(Pl. CXX, figs. 4–6.)

Staurastrum Bieneanum, Rabenh. Alg. Eur. 1862, no. 1410; Wittr. & Nordst. Alg. Exsic. 1877, no. 73; De Toni, Syll. Alg. 1889, p. 1197; West, Alg. W. Ireland, 1892, p. 177; Alg. Engl. Lake Distr. 1892, p. 731; Roy & Biss. Scott. Desm. 1893, p. 178 (sep. p. 17); W. & G. S. West, Alg. Madag. 1895, p. 74; New and Int. Freshw. Alg. 1896, p. 158, t. 3, f. 27; Nordst. Index Desm. 1896, p. 58; W. & G. S. West, Alg. S. England 1897, p. 494; Alga-fl. Yorks, 1901, p. 101; Alg. N. Ireland, 1902, p. 49; Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; Comp. Study

Plankton Irish Lakes, 1906, p. 86; G. S. West, Alg. Yan Yean, 1909, p. 28; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181.

Didymidium (*Staurastrum*) *muticum* c. *Bieneanum* Reinsch, Algenfl. Frank. 1867, p. 151.

Staurastrum orbiculare (Ehrenb.) Menegh. var. *Bieneanum* Rabenh. Flor. Europ. Alg. III, 1868, p. 200.

St. muticum c. *Bieneanum* Riabin. in Bull. Soc. Imp. Natur. Moscou, 1888, no. 2, p. 329.

Cells small, generally a little broader than long, very deeply constricted, sinus widely open with an acuminate apex; semicells subelliptic, dorsal margin less convex than the ventral margin and slightly flattened in the middle, lateral angles subacute. Vertical view triangular, angles subacute (or acutely rounded), sides retuse in the median part. Cell-wall densely and finely punctate.

Zygospore globose, clothed with numerous, simple, stout, slightly curved spines, which are a little dilated at the base and sharp at the apex.

Length 26–37·5 μ; breadth 29–42 μ; breadth of isthmus 7–9 μ; diam. zygosp. without spines 33–35 μ, with spines 50–52 μ; length of spines 8–10 μ.

England. — Borrowdale, Cumberland! Brothers' Water, Westmoreland! Pilmoor, N. Yorks! Epping Forest, Essex! Goring, Oxfordshire (with zygospores)! New Forest, Hants!

Scotland.—Loch Hempriggs and St. John's Loch, Caithness! Kerloch and Blackhall, Kincardine; Balquhadly in Fern, Forfar (*Roy & Bissett*). Benbecula, Outer Hebrides! Orkneys! Plankton of Loch Bairness, Inverness! Plankton of Lochs Cuthaig, Fadaghoda, Roinebhal, and an Tomain, Lewis, Outer Hebrides!

Ireland.—Lough Cloncarney and Sproule's Lough, Donegal! Creggan Lough, Galway! Upper Lake of Killarney, Kerry! Adrigole, Cork! Plankton of Loughs Caragh and Currane, Kerry!

Geogr. Distribution.—Germany. Austria. Norway. Sweden. Bornholm. Faeroes. Nova Zembla. Russia. Siberia. Japan. Siam (var.) New Zealand. Madagascar. E. Africa (var.). United States.

St. Bieneanum, originally described by Rabenhorst as a distinct species, was subsequently placed by that author as a variety of *St. orbiculare* (Ehrenb.) Ralfs. It cannot be considered as a near relative of the latter species, however, and throughout the British Islands it maintains its characters very constantly. The lower margins of the semicells are always more convex than the upper ones, an inequality of curvature which causes a slight outward divergence of the semicells. The dorsal margin is always truncate or faintly retuse in the middle, the angles of both front and vertical views are subacute, and the cell-wall is delicately but distinctly punctate. The zygospores possess fewer, shorter, and stouter spines than those of *St. orbiculare* var. *Ralfsii*.

Forma **spetsbergensis** Nordst. (Pl. CXX, fig. 7.)

St. Bieneanum forma *spetsbergensis* Nordst. Desm. Arctoæ, 1875, p. 32, t. 8, f. 35; Boldt, Siber. Chlorophy. 1885, p. 110; Roy & Biss. Scott. Desm. 1893, p. 178 (sep. p. 17); Börg. Ferskv. alg. Östgrönl. 1894, p. 25; Freshw. Alg. Færoës, 1901, p. 232; Larsen, Freshw. Alg. E. Greenland, 1904, p. 96; Ferskvandsalg. Vest-Grönl. 1907, p. 348.

Cells proportionately a little longer, not quite so deeply constricted; vertical view of triangular form with straight or sometimes slightly convex sides, or of tetragonal form with slightly concave sides. Cell-wall punctate as in the typical form.

Length 35–42 μ; breadth 24–38 μ; breadth of isthmus 10–14 μ.

Scotland.—Near the summit of Lochnagar, Aberdeen (*Roy & Bissett*).

Geogr. Distribution.—Faeroes. Spitzbergen. Greenland. Siberia.

Var. **ellipticum** Wille. (Pl. CXX, fig. 8.)

St. Bieneanum var. *ellipticum* Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 50, t. 13, f. 49; Boldt, Siber. Chlorophy. 1885, p. 111; West, Alg. W. Ireland, 1892, p. 177; Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 109, t. 5, f. 29; W. & G. S. West, Alg. S. England, 1897, p. 494; Schmidle, Lappmark Süsswasseralgen, 1898, p. 58; Lütkem. Desm. Millstättersees, 1900, p. 19; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 348.

Semicells rather narrowly elliptic, angles rounded; cell-wall punctate, with the punctulations arranged in concentric series around the angles.

Length 38–45 μ; breadth 38–45 μ; breadth of isthmus 11–12 μ.

England.—Puttenham Common, Surrey! Keston Common, Kent! New Forest, Hants!

Ireland.—Near Westport, Mayo! Ballynahinch, Loughs Nacoogarrow, Shannacloontippen, and Derryclare, Galway! Lough Guitane, Kerry! Adrigole and Glengariff, Cork!

Geogr. Distribution.—Germany. Austria. Norway (Lappmark). Greenland. Samoa. Australia.

8. **Staurastrum ellipticum** West.

(Pl. CXIX, fig. 7.)

Staurastrum ellipticum West, Alg. Engl. Lake Distr. 1892, p. 731, t. 9, f. 28; Nordst. Index Desm. 1896, p. 117. Lemm. Beitr. Kenntnis Planktonalg. XXVI, 1910, p. 295.

St. muticum Bréb. var. *subsphæricum* Börg. Ferskv. alg. Östgrönl. 1894, p. 24, t. 2, f. 18.

Cells small, about $1\frac{1}{2}$ times longer than broad, fairly deeply constricted, sinus open and acute-angled; semicells somewhat broadly elliptic. Vertical view trigonal, with broadly rounded angles and straight or slightly convex sides, or tetragonal with broadly rounded angles and slightly concave sides. Cell-wall smooth.

Zygospore unknown.

Length 42·5–46 μ; breadth 29–30 μ; breadth of isthmus 13–15 μ.

England.—Borrowdale, Cumberland!

Geogr. Distribution.—Greenland. Paraguay.

This species is nearest to *St. vesiculatum* Wolle ('Freshw. Alg. U.S.,' 1887, p. 42, t. 54, f. 6, 7), from which it differs in its broader sinus and elliptical semicells. It should also be compared with *St. muticum* Bréb. from which it is distinguished by the proportionately greater length, the different shape of the semicells, and the form of the vertical view. The axile chloroplast in each semicell possesses a particularly large central pyrenoid.

9. **Staurastrum coarctatum** Bréb.

(Pl. CXIX, fig. 8.)

Staurastrum coarctatum Bréb. Liste Desm. 1856, p. 144, t. 1, f. 29; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 220; De Toni, Syll. Alg. 1889, p. 1187; Roy & Biss. Scott. Desm. 1893, p. 179; Nordst. Index Desm. 1896, p. 76.

Cells small, a little broader than long, very deeply constricted, sinus open and acute-angled; semicells transversely oblong, with the angles very broadly rounded and slightly divergent, apex faintly retuse. Vertical view triangular, with broadly rounded angles and concave sides. Cell-wall smooth.

Zygospore unknown.

Length 33·3 μ; breadth 38–40 μ; breadth of isthmus 9–5 μ.

Scotland.—Cammie in Strachan, Kincardine (*Roy & Bissett*).

Geogr. Distribution.—France. Sweden (var.). Brazil (var.).

The typical form of this species has only once been observed since its original discovery by Brébisson in 1856. It is recorded by Messrs. Roy and Bissett as "very rare" in one locality in Kincardine.

Var. **subcurtum** Nordst. (Pl. CXIX, figs. 9, 10.)

St. coarctatum var. *subcurtum* Nordst. in Botan. Notiser, 1887, p. 158; Freshw. Alg. N. Zeal. 1888, p. 41, t. 4, f. 20; West, Alg. N. Wales, 1890, p. 293, t. 5, f. 8; Schmidle, Lappmark Süsswasseralgen, 1898, p. 57.

Cells with a wider and more obtuse sinus, isthmus relatively broader and a little elongated; semicells less wide than in the type, lateral angles shorter and not divergent, apex straight or very faintly convex.

Length 20–28 μ; breadth 16–23 μ; breadth of isthmus 6–12 μ.

Wales.—Capel Curig, Carnarvonshire!

Geogr. Distribution.—Norway (Lappmark). New Zealand.

This variety should be compared with *St. muticum*, from

which it differs in its oblong semicells and in the elongation of the isthmus.

The Desmid figured by Bohlin from the Azores under the name of "*St. coarctatum* var. *subcurtum*" (Cf. Bohlin, 'Flor. Algol. d'eau douce d. Açores,' 1901, t. 1, f. 27) is probably a small form of *St. ellipticum*.

10. **Staurastrum grande** Bulnh.

(Pl. CXIX, figs. 11–13; Pl. CXX, fig. 1.)

Staurastrum grande Bulnh. in Hedwigia, 1861, p. 51, t. 9, f. 14; Lund. Desm. Suec. p. 72; Cooke in Grevillea, ix, 1881, p. 91, t. 139, f. 4; Wolle, Desm. U. S. 1884, p. 120, t. 39, f. 3, 4; Cooke, Brit. Desm. 1887, p. 166, t. 57, f. 2; De Toni, Syll. Alg. 1889, p. 1201; Börg. Desm. Brasil. 1890, p. 51; West, Alg. Engl. Lake Distr. 1892, p. 732; Roy & Biss. Scott. Desm. 1893, p. 238; Johnson, Rare Desm. U. S. II, 1895, p. 294; Nordst. Index Desm. 1896, p. 134; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 547; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; Cushman in Bull. Torr. Bot. Club, xxxii, 1905, p. 227, t. 8, f. 17; in Rhodora, vii, 1905, p. 262; W. & G. S. West, Comp. Study Plankton Irish Lakes, 1906, p. 86; G. S. West, Alg. Yan Yean, 1909, pp. 15, 27; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 182; Phytoplankton Engl. Lake Distr. 1909, p. 139.

St. grande forma Lund. Desm. Suec. 1871, p. 72, t. 4, f. 11; Lütkem. Desm. Böhm. 1910, p. 498.

Pleurenterium grande (Bulnh.) Wille in Engler & Prantl, Natürl. Pflanzenfam. 1890, pp. 11, 12 (f. 7 G).

Cells large, about as long as broad, deeply constricted, sinus acute-angled; semicells elliptic or subelliptic, sometimes with the ventral margin more convex than the dorsal margin, lateral angles rather acutely rounded. Vertical view triangular, or very rarely quadrangular, sides slightly retuse, angles acutely rounded. Cell-wall finely punctate. Chloroplasts axile, or sometimes parietal, 3–6 in each semicell, each with 1–3 pyrenoids.

Zygospore angular-globose, furnished with scattered stout spines, arising from a dilated base and often curved.

Length 84–100 μ; breadth 80–111 μ; breadth of isthmus 21–25 μ; diam. zygosp. (of rather small form) without spines 60 μ, with spines 100 μ.

England.—Borrowdale, Cumberland! Loughrigg, and near Bowness; also plankton of Brothers' Water, Westmoreland!

Wales.—Capel Curig, Carnarvonshire (*Cooke & Wills*).

Scotland.—Loch Shin, and plankton of L. nan Cuinne, Sutherland! Near Loch Mharc in the forest of Athole, Perth (*Roy & Bissett*). Plankton of Loch Doon, Ayr!; Lochs Cuthaig and Fadaghoda, Lewis!; Loch nan Eun, N. Uist!; and Loch Laxadale, Harris!

Ireland.—Rare in the plankton of the small lakes between Clifden and Roundstone, Galway!

Geogr. Distribution.—Germany. Austria. Sweden. United States. Brazil. Australia.

St. grande is a rare Desmid, which we have chiefly met with in the plankton of the western lake-areas. The form of the semicells is somewhat variable, some having a much less convex dorsal margin than others. The relative length and breadth of the cells is also slightly variable, and some individuals have more rounded angles than others.

The zygospores have been observed by Cushman from Reading, Mass., U.S.A. This author also describes a var. *glabrum* in which the cell-wall is perfectly smooth. Moreover, the zygospores of this smooth variety are not so angular as those of the type, and are "more densely set with shorter and more slender spines."

The disposition of the chloroplasts in *St. grande* is subject to much variation. Lundell, who was the first to examine them with care, described and figured them as parietal masses. Dr. Lütkemüller, who has recently made a careful study of them in large numbers of individuals, finds all conditions from truly axile to truly parietal chloroplasts, and states that the former condition is the more prevalent.

Var. **parvum** West. (Pl. CXX, figs. 2, 3.)

St. grande var. *parvum* West, New Brit. Freshw. Alg. 1894, p. 11, t. 2, f. 51 [= *St. brevispinum* Bréb. var. *inerme* Wolle, Freshw. Alg. U. S. 1887, t. 62, f. 9, 10 (non Wille, 1879).]

Cells smaller, with a narrower isthmus; angles of semicells more rounded. Cell-wall finely punctate.

Length 61–63 μ; breadth 60–61 μ; breadth of isthmus 13·5–14 μ.

Scotland.—Glen Shee, Perthshire!

Geogr. Distribution.—Lappmark in Norway (forma).

Schmidle ('Lappmark Süsswasseralgen,' 1898, p. 59, t. 3, f. 9) has described a "forma lapponica" of this variety in which the cells are smaller and narrower, with subtruncate apices and slightly thickened angles; length 52 μ, breadth 45 μ.

11. **Staurastrum tumidum** Bréb.

(Pl. CXXII, figs. 1–5.)

Binatella tumida Bréb. Alg. Falaise, 1835, p. 269.

Staurastrum tumidum Bréb. in Ralfs' Brit. Desm. 1848, p. 126, t. 21, f. 6; Arch. in Pritch. Infus. 1861, p. 741; Rabenh. Flor. Europ. Alg. III, 1868, p. 201; Lund. Desm. Suec. 1871, p. 72, t. 4. f. 10; Wolle, Desm. U. S. 1884, p. 120, t. 39, f. 1, 2 [figures poor]; Cooke, Brit. Desm. 1887, p. 165, t. 55, f. 8, t. 57, f. 1; De Toni, Syll. Alg. 1889, p. 1201; West, Alg. W. Ireland, 1892, p. 180; Alg. Engl. Lake Distr. 1892, p. 732; Roy & Biss. Scott. Desm. 1893, p. 244 (sep. p. 26); Nordst. Index Desm. 1896, p. 263; W. & G. S. West, Alg. S. England, 1897, p. 494; Schmidle, Lappmark Süsswasseralgen, 1898, p. 58; W. & G. S. West, Alga-fl. Yorks. 1901, p. 103; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; Brit. Freshw. Phytoplankton, etc., 1909, p. 183.

Phycastrum tumidum Kütz. Spec. Alg. 1849, p. 179.

Pleurenterium tumidum (Bréb.) Wille in Engler & Prantl, Natürl. Pflanzenfam. 1890, p. 11.

Temperea tumida (Bréb.) Bougon in Le Micrographe préparateur, v, 1897, p. 68.

Cells very large, a little longer than broad, deeply constricted, sinus open and acute-angled with a slightly rounded apex; semicells very broadly subelliptic, apex generally a little flattened and sometimes faintly concave in the middle, lateral angles with a small button-like thickening, which is sometimes replaced by a small, solid mamilla. Vertical view triangular (rarely quadrangular), with strongly convex sides, and a small projecting mamilla at each angle. Cell-wall punctate. Chloroplasts forming 4–6 (?) parietal cushions in each semicell.

Zygospore ovoid-oblong, with a thick lamellose wall, furnished with a few, irregularly scattered, conical papillæ.

Length 112–134 μ; breadth 90–127 μ; breadth of isthmus 44–50 μ; length of zygosp. without papillæ 176 μ, breadth 92 μ; length of papillæ 14 μ.

England.—Cumberland! Westmoreland! (*Bissett*).

Lancashire! Ilkley, W. Yorks (*W. H. Dikes*). Surrey! Sussex (*Ralfs*). Hants! Devon! Cornwall!

Wales.—Capel Curig! (*Cooke and Wills*), Llyn Padarn, and near Dolbadarn Castle, Carnarvonshire! Dolgelly, Merioneth! (*Ralfs*). Plankton of several of the Welsh lakes!

Scotland.—Sutherland! Ross! Aberdeen, Kincardine, Forfar, Perth! (*Roy & Bissett*). Plankton of Loch Luichart, Ross! Lewis, Outer Hebrides!

Ireland.—Near Westport, Mayo! Callery Bog, Galway (*Archer*). Carantuohill, Kerry! Dublin and Wicklow (*Archer*).

Geogr. Distribution.—France. Germany. Galicia in Austria. Norway. Denmark. Sweden. Bornholm. United States.

St. tumidum is one of the largest and most distinctive British species of the genus. The cells are usually enveloped in a large mucilaginous envelope, which may attain a diameter of 196 μ.

The semicells vary a little in outward form in front view (Consult Pl. CXXII, figs. 1 and 3 *a*). The form with the triangular vertical view is much the commonest, but tetragonal forms are sometimes met with, and we have on one occasion observed an irregularly pentagonal form. The mamillate thickening at each angle is sometimes prominent, but in other individuals it may be rather obscure.

12. **Staurastrum conspicuum** W. & G. S. West.

(Pl. CXXI, figs. 1, 2.)

Staurastrum conspicuum W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 547, t. 14, f. 4; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; British Freshw. Phytoplankton, etc. 1909, p. 181.

Cells very large, about $1\frac{1}{6}$ times broader than long, very deeply constricted, sinus linear in the median part, widely open outwards, and dilated at its extremity; semicells elliptic-fusiform, dorsal margin convex but widely truncate in the middle, lateral angles strongly thickened and mamillate. Vertical view triangular, sides widely concave, angles acutely

rounded and mamillate. Cell-wall delicately punctate-scrobiculate.

Zygospore unknown.

Length 83–103 μ; breadth 111–134 μ; breadth of isthmus 21–27 μ.

Scotland.—In the plankton of Loch Shin and Loch Ghriama; also in a small pool at Rhiconich, Sutherland!

One of the largest and most striking species of the genus, *St. conspicuum* can be compared with *St. majusculum* Wolle, from which it differs in the form of its semicells, its sinus, and the form of the vertical view. From *St. grande* it is at once distinguished by the entirely different sinus, the shape of its semicells, and the mamillate angles.

13. **Staurastrum aversum** Lund.

(Pl. CXX, figs. 9–13.)

Staurastrum aversum Lund. Desm. Suec. 1871, p. 59, t. 3, f. 27; Cooke in Journ. Quekett Micr. Club, 1881, p. 206, t. 16, f. 36; Brit. Desm. 1887, p. 166, t. 55, f. 6; De Toni, Syll. Alg. 1889, p. 1202; West, Alg. N. Wales, 1890, p. 294; Roy & Biss. Scott. Desm. 1893, p. 178; Nordst. Index Desm. 1896, p. 54; W. & G. S. West, Notes Alg. III, 1903, p. 75; Scott. Freshw. Plankton, I. 1903, p. 529; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; Comp. Study Plankton Irish Lakes, 1906, p. 86; Brit. Freshw. Phytoplankton, etc., 1909, p. 181.

Cells of medium size, about $1\frac{1}{4}$ times as long as broad, deeply constricted, sinus acute-angled and widely open; semicells obversely elliptic-semicircular, apex truncate or slightly retuse (rarely convex), ventral margin very strongly convex, angles broadly rounded, each furnished with a minute papilla. Vertical view triangular, with broadly rounded angles and slightly concave sides, each angle furnished with a minute papilla. Cell-wall very delicately punctate.

Zygospore unknown.

Length 35–58 μ; breadth 29–45 μ; breadth of isthmus 10–17 μ.

Wales.—Capel Curig! (*Cooke & Wills*), near Llanfairfechan, and Llyn-y-cwm-ffynon, Carnarvonshire! Plankton of several of the Welsh lakes!

Scotland.—Rhiconich, plankton of Lochs Shin and Nan Cuinne, Sutherland! Plankton of Loch Shiel, Inverness! Near Aboyne, Aberdeen; Cammie, Kincardine (*Roy & Bissett*). Plankton of Loch Fadaghoda and four other lochs in Lewis; plankton of Loch nan Eun, N. Uist; and plankton of Loch Mhorgain, Harris, Outer Hebrides!

Ireland.—Plankton of small lakes between Clifden and Roundstone, and of Lough Corrib, Galway!

Geogr. Distribution.—Norway. Sweden. United States.

This characteristic species is practically confined to the western lake-areas of the British Islands. It is most nearly allied to *St. brevispinum*, but need never be confused with that species, differing in the form of its semicells, in the nature of its sinus, and in the less retuse sides of the vertical view. We regard it as a very distinct species with a very definite geographical distribution. It exhibits little variation except in size.

14. **Staurastrum brevispinum** Bréb.

(Pl. CXXIII, figs. 1–3.)

Binatella brevispina Bréb. in Cheval. microscop. et usage, 1839, p. 272.

Staurastrum brevispinum Bréb. in Ralfs' Brit. Desm. 1848, p. 124, t. 34, f. 7 *a* et *b*; Arch. in Pritch. Infus. 1861, p. 737; Rabenh. Flor. Europ. Alg. III, 1868, p. 202; Kirchn. Alg. Schlesien, 1878, p. 168; Wolle, Desm. U. S. 1884, p. 121, t. 53, f. 2, 3; Cooke, Brit. Desm. 1887, p. 140, t. 49, f. 4; Hansg. Prodr. Algenfl. Böhm. 1888, p. 211; De Toni, Syll. Alg. 1889, p 1140; West, Add. Alg. W. Yorks. 1891, p. 247; Alg. Engl. Lake Distr. 1892, p. 730; Lütkem. Desm. Attersees, 1893, p. 563; Roy & Biss. Scott. Desm. 1893, p. 179 (sep. p. 18); Nordst. Index Desm. 1896, p. 69; W. & G. S. West, Alg. S. England, 1897, p. 492; Schmidle, Lappmark Süsswasseralgen, 1898, p. 50; W. & G. S. West. Alga-fl. Yorks. 1900, p. 97; Borge, Süsswasseralgen Süd-Patagon. 1901, p. 27; W. & G. S. West, Alg. N. Ireland, 1902, p. 44; Freshw. Alg. Orkneys and Shetlands, 1905, p. 24. t. 1, f. 32; Further Contrib. Freshw. Plankton Scott. Lochs. 1905, p. 486; Comp. Study Plankton Irish Lakes, 1906, p. 86; Borge, Beiträge Alg. Schweden, 1906, p. 44; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 348; W. & G. S. West, British Freshw. Phytoplankton, etc., 1909, p. 181.

St. brevispinum forma *minor* Rabenh. Flor. Europ. Alg. III, 1868, p. 202; Boldt, Siber. Chlorophy. 1885, p. 113; Larsen, Freshw. Alg. E. Greenland, 1904, p. 96.

St. muticum Bréb. var. *brevispinum* (Bréb.) Jacobs. Desm. Danem. 1876, p 202.

St. brevispinum var. *minor* Roy & Biss. Jap. Desm. 1886, p. 237.

St. brevispinum forma *hexagona* Eichl. & Gutw. Nonn. spec. alg. nov. 1894, p. 175, t. 5, f. 48.

Cells rather under medium size, about as long as broad, deeply constricted, sinus open and acute-angled, very narrow at the extremity; semicells oblong-elliptic, ventral margin frequently more convex than dorsal margin, apex convex, subtruncate, or sometimes slightly retuse in the middle, lateral angles rounded and furnished with a small mucro or papilla. Vertical view triangular, with concave sides and rounded angles, each angle furnished with a small mucro. Cell-wall smooth.

Zygospore unknown.

Length 27–50 μ; breadth 27–49 μ; breadth of isthmus 8–17 μ.

England.—Westmoreland! (*Bissett*). Hawkshead and Hampsfell, Lancashire! Malham Tarn, W. Yorks! Gormire and Pilmoor, N. Yorks! Riccall Common, E. Yorks! Thursley Common, Surrey! Sussex (*Ralfs*). New Forest, Hants! (*Roy*). Cornwall (*Ralfs*).

Wales.—Capel Curig, Carnarvonshire! Plankton of Llyn Ogwen!

Scotland.—Sutherland, Inverness!, Aberdeen, Kincardine, Forfar, Perth (*Roy & Bissett*). Plankton of Loch Shiel, Inverness! Loch Stranabhat, Lewis, Outer Hebrides! Plankton of Shetlands!

Ireland.—E. of Glenties, Donegal! Plankton of lakes in Mayo, Galway, and Kerry! Dublin and Wicklow (*Archer*). Plankton of Loughs Neagh and Beg! Lough Fea, Londonderry!

Geogr. Distribution.—France. Germany. Switzerland. Austria and Galicia. Hungary. Macedonia. Servia. Italy. Norway. Sweden. Denmark. Bornholm. Poland. N. Russia (var.). Iceland. Greenland. Nova Zembla. Siberia. India. Abyssinia (var.). Central Africa. United States. Paraguay. Patagonia.

St. brevispinum is a well-marked and widely distributed species. It is distinguished from *St. aversum* by the shape of the semicells and the sinus, the latter being almost mucronate at the extremity. The short papillæ at the angles

are similar to those in *St. aversum*, but in most cases are rather stronger and firmer. Owing to the varying degrees of convexity of the lower margin of the semicells the position of the angular papillæ is not quite constant, and they sometimes have a distinct upward direction (Consult Pl. CXXIII, figs. 3 *a* and *a'*).

The zygospores recorded by Cushman ('Bull. Torr. Bot. Club,' xxxii, 1905, p. 226, t. 8, f. 12, 13) under the name of *St. brevispinum* do not appear to us to belong to this species, but rather to some form of *St. Dickiei*. The angles of the semicells as figured by Cushman are much too acutely rounded (exclusive of the short spines) for any form of *St. brevispinum*.

Lütkemüller ('Desm. Millstättersees,' 1900, p. 78) has described a "forma *minima*" of this species (length 20 μ; breadth 22·5 μ; breadth of isthmus 7·5 μ).

Forma **major** W. & G. S. West. (Pl. CXXIII, fig. 4.)

St. brevispinum forma *major* W. & G. S. West, Phytoplankton Engl. Lake Distr. 1909, p. 290, f. 6 E (p. 291).

Cells larger and somewhat inflated.

Length 59–63 μ; breadth 52–57 μ; breadth of isthmus 16–17 μ.

England.—Plankton of Thirlmere, Cumberland! Plankton of Brothers' Water and Ullswater, Westmoreland!

Var. **Boldtii** Lagerh.

St. brevispinum forma Boldt, Siber. Chlorophy. 1885, p. 113, t. 5, f. 30.
St. brevispinum var. *Boldtii* Lagerh. Chlor. Abessin. u. Kordofan, 1893, p. 163.
St. brevispinum forma *Boldtii* Turn. Freshw. Alg. E. India, 1893, p. 130, t. 16, f. 45 (?).

Cells proportionately longer, semicells more broadly elliptic.

Length 47 μ; breadth 35 μ; breadth of isthmus 13·5 μ.

Geogr. Distribution.—Siberia. Abyssinia. India (?).

This variety as figured by Boldt does not occur in the British Islands, but a form of it is known from Scotland:—

Forma RETUSA (Borge) *nob.* *St. brevispinum* var. *retusum* Borge, Süssw. Chlor. Archang. 1894, p. 36, t. 3, f. 42; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 546, t. 14, f. 6.

Apex of semicell slightly retuse in the middle, angles of semicells very broadly rounded. (Pl. CXXIII, fig. 6.)

Length 43–52 μ; breadth 36–41 μ; breadth of isthmus 13–14 μ.

SCOTLAND.—Loch Nan Cuinne and Loch Ruar, Sutherland! (*J. Murray*). Loch Fadaghoda, Lewis, Outer Hebrides! *Geogr. Distribution.*—N. Russia.

Var. **altum** W. & G. S. West. (Pl. CXXIII, fig. 5.)

St. brevispinum var. *altum* W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 502, t. 7, f. 16; Comp. Study Plankton Irish Lakes, 1906, p. 86; Brit. Freshw. Phytoplankton, etc., 1909, p. 181.

Cells longer than broad, dorsal margin of semicells very strongly convex (almost subsemicircular); in the vertical view with the sides less concave and the angles thicker.

Length 57–66 μ; breadth 43–50 μ; breadth of isthmus 12·5–15·3 μ.

SCOTLAND.—Plankton of Lochs Nan Cuinne and Ruar, Sutherland! (*J. Murray*); Lochs Fadaghoda, an Sgath, and an Tomain, Lewis; and Loch Diracleet, Harris, Outer Hebrides!

IRELAND.—Plankton of Lough Corrib, Galway!

Var. **obversum** W. & G. S. West. (Pl. CXXIII, fig. 7.)

St. brevispinum var. *obversum* W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 502, t. 7, f. 15; British Freshw. Phytoplankton, etc., 1909, p. 181.

Cells broader than long, sinus narrow and sublinear towards the extremity; semicells obversely semi-elliptic, with a prominent papilla at each superior angle, dorsal margin slightly convex, ventral margin very strongly convex.

Length 38–42 μ; breadth 45–49·5 μ; breadth of isthmus 10·5–11 μ.

SCOTLAND.—Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

Var. **inerme** Wille.

St. brevispinum var. *inerme* Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 52, t. 13, f. 62.

Cells larger, sinus more open with a rounded extremity, isthmus wider; sides of vertical view less retuse; angles of semicells destitute of a papilla or mucro.

Length 73 μ; breadth 60 μ; breadth of isthmus 24 μ.

England.—Woodbury Common, Devonshire! (*R. Moryan*).

Geogr. Distribution.—Nova Zembla. United States (?).

It is possible that this variety should be relegated elsewhere. The rounded sinus and the entire absence of the small mucros are characters which separate it somewhat widely from all other known forms of *St. brevispinum*.

15. **Staurastrum lanceolatum** Arch.

(Pl. CXXI, figs. 3–6.)

Staurastrum lanceolatum Arch. Descript. New Cosm. etc. 1862, p. 79, t. 2, f. 16–22; Rabenh. Flor. Europ. Alg. III, 1868, p. 202; Nordst. Desm. Spetsb. 1872, p. 38; Desm. Arctoæ, 1875, p. 33 [forms]; Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 51; Cooke, Brit. Desm. 1887, p. 158, t. 54, f. 2; De Toni, Syll. Alg. 1889, p. 1182; West, Alg. N. Wales, 1890, p. 293; Alg. W. Ireland, 1892, p. 178; Roy & Biss. Scott. Desm. 1893, p. 22 (sep.); Nordst. Index Desm. 1896, p. 155; W. & G. S. West, Alg. S. England, 1897, p. 493; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 350.

Cells very small, about as long as broad, very deeply constricted, sinus open and acute-angled, sides of sinus almost straight; semicells elliptic-lanceolate, dorsal margin more convex than the ventral margin, lateral angles acute and minutely apiculate (although the apiculus is sometimes difficult to detect). Vertical view triangular (or more rarely quadrangular), angles very slightly inflated and minutely apiculate, sides concave in the middle. Cell-wall smooth.

Zygospore globose, furnished with numerous, slender, acute spines.

Length 15–29 μ; breadth 15–28 μ; breadth of

isthmus 9–14 μ; diam. zygosp. without spines 22–25 μ, with spines 37–40 μ.

England.—Borrowdale, Cumberland! Thursley Common, Surrey! New Forest, Hants (with zygospores)! Near St. Just and Halgavor Moor, Cornwall!

Wales.—Capel Curig!, and Glyder Fawr (*Roy*), Carnarvonshire.

Scotland.—Ross, Aberdeen, Kincardine, Forfar, Perth; zygospores from Aberdeen and Kincardine (*Roy & Bissett*). Glen Nevis, Inverness!

Ireland.—Lough Clogher, and Errigal, Donegal! Adrigole, Cork! Dublin and Wicklow (*Archer*).

Geogr. Distribution.—Germany. Bavaria. Sweden. Nova Zembla. Spitzbergen. Greenland. United States.

St. lanceolatum is a rare species with very distinct characters. The quadrangular forms appear to be mostly confined to arctic areas.

In the above description we have combined the three forms (f. *minor*, f. *media*, and f. *major*) mentioned by Nordstedt in his 'Desm. Arctoæ,' p. 33, as it is unwise to draw arbitrary lines of demarcation such as would be required to separate these forms.

Var. **compressum** W. & G. S. West. (Pl. CXXI, fig. 7.)

St. lanceolatum var. *compressum* W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 11, t. 1, f. 22; Some N. Amer. Desm. 1896, p. 261; Alg. S. England, 1897, p. 493.

Cells somewhat compressed, sinus narrower especially at the extremity; apex of semicells flattened; sides of vertical view more distinctly concave.

Length 17·3–17·5 μ; breadth 21–21·2 μ; breadth of isthmus 7·5 μ.

England.—New Forest, Hants!

Scotland.—Lewis, Outer Hebrides!

Geogr. Distribution.—United States.

16. **Staurastrum pachyrhynchum** Nordst.

(Pl. CXXI, figs. 8, 9.)

Staurastrum pachyrhynchum Nordst. Desm. Arctoæ, 1875, p. 32, t. 8, f. 34; Boldt, Siber. Chlorophy. 1885, p. 111; De Toni, Syll. Alg. 1889, p. 1185; Borge, Bidr. Siber. Chlor. 1891, p. 9, t. 1, f. 5; Roy & Biss. Scott. Desm. 1893, p. 241 (sep. p. 23); Börg. Ferskv. Alg. Östgrönl. 1894, p. 24, t. 2, f. 19, 20 [forms]; Nordst. Index Desm. 1896, p. 193; W. & G. S. West, Alg. S. England, 1897, p. 494; Some Desm. U. S. 1898, p. 314; Larsen, Freshw. Alg. E. Greenland, 1904, p. 99; Ferskvandsalg. Vest-Grönl. 1907, p. 351.

Cells somewhat small, about as long as broad, deeply constricted, sinus open, subrectangular or acute-angled; semicells subelliptic or elliptic-subtriangular, dorsal margin subtruncate, convex or strongly convex, angles very slightly (almost imperceptibly) produced, rounded-obtuse, usually with a very faint upward tilt. Vertical view 3–5-angular, sides concave, angles rounded-obtuse. Cell-wall smooth or very delicately punctate, very strongly thickened at the angles.

Zygospore unknown.

Length 28–45 μ; breadth 22–45 μ; breadth of isthmus 8–15 μ.

England.—Thursley Common, Surrey! New Forest, Hants!

Wales.—Capel Curig, Carnarvonshire!

Scotland.—Slewdrum and Heughhead near Aboyne, Aberdeen (*Roy & Bissett*).

Ireland.—Dublin and Wicklow (*Archer*).

Geogr. Distribution.—Germany. Austria (var.). Sweden. Poland (var.). Nova Zembla. Spitzbergen. Greenland. Siberia. United States. Paraguay (form).

In British and American specimens we have found the thickened angles of the semicells directed horizontally in the front view. In arctic specimens they appear usually to have a faint upward or divergent tilt. In a form described by Raciborski as "var. *convergens*" (Racib. 'Desm. Nowe,' 1889, p. 98, t. 7, f. 14), and known to occur in Poland, Germany, and Austria, the angles of the semicells are decidedly convergent.

We do not agree with Stockmayer (in 'Österr. botan.

Zeitschr.' 1906, no. 2, p. 6) in regarding this species as a form of *St. Clepsydra* Nordst.

17. **Staurastrum Clepsydra** Nordst.

(Pl. CXXII, fig. 6.)

Staurastrum Clepsydra Nordst. Desm. Brasil. 1870, p. 224, t. 4, f. 47 [*α obtusum* and *β acuminatum*]; Lagerh. Bidr. Amerik. Desm.-fl. 1885, p. 46; De Toni, Syll. Alg. 1889, p. 1139; Roy & Biss. Scott. Desm. 1893, p. 179.

Cells small, as broad as long or a little broader; very deeply constricted, sinus widely open, subrectangular or acute-angled; semicells obversely subtriangular, sides convex, apex straight or convex, angles very slightly produced and sometimes submucronate. Vertical view triangular, sides very slightly concave, angles very little rounded and sometimes submucronate. Cell-wall smooth.

Zygospore unknown.

Length 27–31 μ; breadth 27–36 μ; breadth of isthmus 6–8 μ.

Scotland.—Achnerran in Logie-Coldstone, Aberdeen (*Roy & Bissett*).

Geogr. Distribution.—Norway. Sweden. Poland. Spitzbergen. Greenland. United States. Brazil.

The characters of this species are a little obscure, and we have not personally seen any Desmid exactly agreeing with Nordstedt's original figure. We are, however, acquainted with a small Desmid, described by Borge in 1891 as "*St. sibiricum*," which we think cannot with justice be separated from *St. Clepsydra*.

Var. **sibericum** (Borge) *nob.* (Pl. CXXII, figs. 7, 8.)

Staurastrum sibiricum Borge, Bidr. Siber. Chlor. 1891, p. 9, t. 1, f. 4 forma *ovalis*]; W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 502, t. 7, f. 20; Brit. Freshw. Phytoplankton, etc., 1909, p. 183.

Cells smaller and less deeply constricted. Vertical view fusiform or triangular.

Forma ovalis Borge, l. c. Vertical view fusiform, poles slightly rounded and almost imperceptibly produced. Length 17–20 μ; breadth 17–21 μ; breadth of isthmus 7·5–8·5 μ; thickness 8–9 μ.

Scotland.—Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

Geogr. Distribution.—Siberia.

Forma trigona nob. *St. sibericum* Borge forma *trigona* W. & G. S. West, New and Int. Freshw. Alg. 1896, p. 157, t. 4, f. 39; Alg. S. England, 1897, p. 493; Some Desm. U. S. 1898, p. 312. Vertical view triangular with slightly concave sides and subacute angles. Length 13·5–16·5 μ; breadth 15–16 μ; breadth of isthmus 3·8–8·5 μ.

England.—Devil's Jumps, Frensham Common, Surrey!

Geogr. Distribution.—United States.

One specimen of this form was noticed with a wide gelatinous investment 39 μ in diameter.

18. **Staurastrum inelegans** W. & G. S. West.

(Pl. CXXIV, figs. 2–4.)

Staurastrum inelegans W. & G. S. West, Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 501, t. 7, f. 11, 12; Brit. Freshw. Phytoplankton, etc., 1909, p. 182.

Cells of medium size, as long as broad or a little broader, deeply constricted, sinus very wide and obtusely rounded at the extremity, isthmus shortly cylindrical; semicells widely subtriangular, inferior margins almost straight or slightly biundulate, dorsal margin (apex) convex in the middle, angles produced, acute or apiculate (rarely subobtuse). Vertical view triangular, sides convex in the middle, angles submamillate and slightly apiculate. Cell-wall smooth.

Zygospore unknown.

Length 53·5–60 μ; breadth 51–62 μ; breadth of isthmus 9–10 μ.

Scotland.—Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

This remarkable *Staurastrum*, so far only observed from the one locality, is somewhat variable in its characters. The angles of the semicells are generally produced, and either acute or apiculate, but in some specimens they are relatively

obtuse. They may be horizontally disposed, but are more often slightly turned upwards. The shortly cylindrical isthmus is also characteristic.

St. inelegans undoubtedly stands near to *St. Clepsydra*, but differs in its more produced angles, its more elevated apices, its elongated isthmus, and in the form of the vertical view. It is also a larger species.

19. **Staurastrum angulatum** West.

(Pl. CXXIII, figs. 8, 9.)

Staurastrum angulatum West, Desm. Mass. 1889, p. 20, t. 3, f. 20; Nordst. Index Desm. 1896, p. 44.

Cells of medium size, about $1\frac{1}{4}$ times as long as broad, deeply constricted, sinus widely open and acute-angled; semicells rhomboid with straight sides and very slightly rounded angles. Vertical view triangular, sides faintly retuse in the middle, angles a little inflated and subacute. Cell-wall smooth.

Zygospore unknown.

Length 76–79 μ; breadth 60–62 μ; breadth of isthmus 17–18·5 μ.

Geogr. Distribution.—United States.

The typical form of this species is not known to occur in the British Islands. It was originally found in collections from Amherst, Massachusetts. There is a faint indication of an obscure mucro at the angles of the semicells.

Var. **planctonicum** W. & G. S. West. (Pl. CXXIII, fig. 10.)

St. angulatum var. *planctonicum* W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 551; t. 16, f. 10; Brit. Freshw. Phytoplankton, etc., 1909, p. 181.

Cells smaller, almost as broad as long, semicells rhomboid-depressed, each angle furnished with a small apiculus.

Length 47 μ; breadth 44–46 μ; breadth of isthmus 9·5–10·5 μ.

Scotland.—Plankton of Loch Shin, Sutherland!

20. **Staurastrum orbiculare** Ralfs.

(Pl. CXXIV, figs. 10, 11.)

? *Desmidium orbiculare* Ehrenb., 1834; Infus. 1838, p. 141, t. 10, f. ix.

Staurastrum orbiculare [? Menegh. Synops. Desm. 1840, p. 225]; Ralfs in Ann. Mag. Nat. Hist. xv, 1845, p. 152, t. 10, f. 4; Ralfs, Brit. Desm. 1848, p. 125, t. 21, f. 5 *h* and *i*? [not figs. 5 *a–g*]; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 200; Lund. Desm. Suec. 1871, p. 56; Delp. Desm. subalp. 1877, p. 37, t. 10, f. 11 and 12 [not f. 5–10]; ? Wolle, Desm. U. S. 1884, p. 120, t. 39, f. 9, 10; ? De Toni, Syll. Alg. 1889, p. 1180; Nordst. in Wittr., Nordst. & Lagerh. Alg. Exsic. 1903, no. 1472; fasc. 35, 1903, p. 9 [in part].

Goniocystis (*Trigonocystis*) *orbicularis* Hass. Brit. Freshw. Alg. 1845, p. 349, t. 84, f. 7.

Phycastrum orbiculare Kütz. Phyc. germ. 1845, p. 137.

Didymidium (*Staurastrum*) *orbiculare* Reinsch, Algenfl. Frank. 1867, p. 152 [in part].

? *Staurastrum orbiculare* forma *punctata* Gutw. Wahr. d. Priorität, 1890, p. 71; Flor. Glon. Okolic Lwowa, 1891, p. 65, t. 3, f. 10.

St. Farquharsonii, Roy & Biss. Scott. Desm. 1893, p. 237, t. 4, f. 3.

St. hibernicum West var. *Farquharsonii* (Roy & Biss.) W. & G. S. West, Notes Alg. II, 1900, p. 296, t. 412, f. 21.

Cells of medium size, a little longer than broad, almost circular in general outline, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells subsemicircular, apex a little depressed but scarcely truncate, basal angles somewhat rounded. Vertical view triangular, sides slightly concave, angles broadly rounded. Cell-wall punctate.

Zygospore unknown.

Length 54·4–56 μ; breadth 46·5–49 μ; breadth of isthmus 11–12·5 μ.

England.—Hampsfell, Lancashire! Cornwall (*Ralfs*).

Scotland —Alford, Aberdeen (*Roy & Bissett*).

Geogr. Distribution.—Germany. Austria (?). Sweden. Finland. Italy.

The Desmid described above must be taken as the type form of *St. orbiculare*, as it is identical with the *Staurastrum* described and figured by Ralfs in 1845 under that name. Ralfs identified his plant with "*Desmidium orbiculare* Ehrenb.," but as that is open to some doubt, we regard Ralfs as the author of the species.

In 1848, although Ralfs did not alter his description, he included other forms among his figures. Thus, of the figures in his 'British Desmids,' t. 21, only figs. 5 *h* and *i* represent typical *St. orbiculare*, and even these figures are not good.

Ralfs' figs. 5 *a–g* represent another form of the species which we have here named "var. *Ralfsii*." This is the form which most authors, ourselves included, have until recently regarded as the type form of the species, an error due to the fact first pointed out by Nordstedt in 1903, that no one had taken the trouble to go back to Ralfs' original account in the 'Annals and Magazine of Natural History' for 1845.

St. Farquharsonii Roy & Biss. is this species in its most typical form.

Var. **hibernicum** *nob.* (Pl. CXXIV, figs. 5–9.)

St. orbiculare forma in Wittr. & Nordst. Alg. Exsic. 1878, no. 167.

? *St. cordatum* Gay, Monogr. loc. Conj. Montpellier, 1884, p. 65, t. 2, f. 7; De Toni, Syll. Alg. 1889, p. 1194.

St. hibernicum West, Alg. W. Ireland, 1892, p. 177, t. 23, f. 6; Alg. Engl. Lake District, 1892, p. 731; Notes Alg. II, 1900, p. 296, t. 412, f. 20.

St. orbiculare var. *extensum* Nordst. forma *major* Schmidle, Beitr. alp. Alg. 1896, p. 61.

St. orbiculare in Nordst., Wittr., & Lagerh. Alg. Exsic. 1903, no. 1472; fasc. 35, 1903, p. 9 [in part], f. 1–6 (p. 10).

Cells often a little larger than the type; semicells with the basal angles less rounded and the apex broadly truncate; vertical view somewhat variable in the width of the angles; cell-wall punctate as in the type.

Length 42–65 μ; breadth 36–56 μ; breadth of isthmus 9·5–20 μ.

England.—Near Bowness and Loughrigg, Westmoreland!

Ireland.—Near Westport, Mayo!

Geogr. Distribution.—France (?). Austria. Sweden.

This is the largest form of *St. orbiculare* and is principally characterized by the more pronounced basal angles of the semicells and the flattened apices.

Var. **Ralfsii** *var. nov.* (Pl. CXXIV, figs. 12, 13, 15, 16.)

St. orbiculare Ralfs, Brit. Desm. 1848, t. 21. f. 5 *a–g* [not 5 *h* and *i*]; Delp. Desm. subalp. 1877, p. 37 (sep. p. 133), t. 10, f. 8–10; Wille, Fersky. Alg. Nov. Semlj. 1879, p. 49; Gay, Monogr. loc. Conj. Montpellier, 1884, p. 65; Cooke, Brit. Desm. 1887, t. 51, f. 7 [figures poor]; Hansg. Prodr. Algenfl. Böhm. 1888, p. 254; West, Alg. N. Wales, 1890, p. 293; Alg. W. Ireland, 1892, p. 176; Alg. Engl. Lake Distr. 1892, p. 731; Roy & Biss. Scott. Desm. 1893, p. 23 (sep.); W. & G. S. West, Alg. S. Engl. 1897, p. 494; Alga-fl. Yorks. 1900, p. 100; Alg. N. Ireland, 1902, p. 49;

Scott. Freshw. Plankton, I. 1903, p. 529; Freshw. Alg. Orkneys & Shetlands, 1905, p. 25; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; Brit. Freshw. Phytoplankton, etc., 1909, p. 182.

Semicells subtriangular, basal angles and apex rounded, sides slightly convex; cell-wall smooth.

Zygospore globose, furnished with numerous, simple, acute spines.

Length 31–41 μ; breadth 22–36 μ; breadth of isthmus 7–11 μ; diam. zygosp. without spines 36–40 μ, with spines 60–66 μ.

England.—Cumberland! Westmoreland! Lancashire! W., N., and E. Yorks! Cheshire (*Roy*). Leicestershire (*Roy*). Bucks! Warwick (*Wills*). Sussex! Kent! Hants! Devon! Cornwall!

Wales.—General (but scarce)!

Scotland.—General, and often conjugated (*Roy & Bissett*). Inverness! Ayr! Wigtown! Lewis, Outer Hebrides! Orkneys! Shetlands! Rare in the plankton!

Ireland.—Donegal! Mayo (and Clare Island)! Galway! Kerry! Dublin and Wicklow (*Archer*). Down! Londonderry!

Geogr. Distribution.—France. Germany. Switzerland. Austria and Galicia. Hungary. Servia. Italy. Portugal. Norway. Sweden. Denmark. Bornholm. Finland. Poland. N., Central, and S. Russia. Faeroes. Iceland. Nova Zembla. Spitzbergen. Greenland. E. and N. India. Australia. United States. Brazil. Bolivia. Paraguay. Argentina. Patagonia.

This is much the most abundant and widely distributed of all the forms of *St. orbiculare*, and one which has generally been accepted as the type form. We have ourselves invariably, although erroneously, recorded it as such. Its most important character is the elevated apex of the semicell, giving the latter a subtriangular outline. This variety and var. *extensum* Nordst. are the only forms of *St. orbiculare* of which the zygospores are known.

A large form—forma major [= *St. orbiculare* f. *major* West, 'Alg. Engl. Lake Distr.' 1892, p. 731]—is known from near Bowness, Westmoreland; length 61 μ; breadth 50 μ; breadth of isthmus 17·5 μ.

Var. **depressum** Roy & Biss. (Pl. CXXIV, figs. 17–19.)

St. orbiculare var. *depressum* Roy & Biss. Jap. Desm. 1886, p. 237, t. 268, f. 14; Nordst. Freshw. Alg. N. Zeal. 1888, p. 42; West, Alg. W. Ireland, 1892, p. 177; Alg. Engl. Lake Distr. 1892, p. 731; W. & G. S. West, Alg. S. England, 1897, p. 494; Alga-fl. Yorks. 1900, p. 100; Freshw. Chlorophy. Koh Chang, 1901, p. 178; Alg. N. Ireland, 1902, p. 49; Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Brit. Freshw. Phytoplankton, etc., p. 182.

Cells small, as long as broad, semicells much depressed; cell-wall smooth.

Length 22–27 μ; breadth 20–27 μ; breadth of isthmus 6–7·5 μ.

England.—Near Bowness, Westmoreland! Hawkshead, Lancashire! Malham Tarn and near Clapham, W. Yorks! Pilmoor and Strensall, N. Yorks! Riccall and Skipwith Commons, E. Yorks! Dernford Fen and Wicken Fen, Cambridge! Chobham and Witley Commons, Surrey! New Forest, Hants! Near the Lizard, Cornwall!

Wales.—Llyn Idwal and Y Foel Fras, Carnarvonshire! Brecon!

Scotland.—Rhiconich, Sutherland! At 3500 ft. on Lochnagar, Aberdeen! Ben Laoigh, Perth! Tents Moor, Fife (*Roy & Bissett*). Renfrew! Near Loch Doon, Ayr! Orkneys and Shetlands, in both the bogs and the plankton!

Ireland.—Donegal! Mayo! Galway! Kerry! Londonderry!

Geogr. Distribution.—Galicia in Austria. Sweden. N. Russia. Central China. Japan. Siam. Australia. New Zealand. Madagascar.

Var. **extensum** Nordst. (Pl. CXXV, figs. 1, 2.)

St. orbiculare var. *extensum* Nordst. Norges Desm. 1873, p. 26, t. 1, f. 10; Desm. Ital. 1876, p. 42; West, Alg. Eng. Lake Distr. 1892, p. 731; Notes Alg. II, 1900, p. 296, t. 412, f. 19; Alga-fl. Yorks, 1900, p. 100.

Cells 1$\frac{1}{3}$ times as long as broad; semicells relatively higher and more inflated.

Zygospores exactly similar to those of var. *Ralfsii*.

Length 38–48 μ; breadth 25·5–36 μ; breadth of isthmus 8–14 μ.

England.—Stye Head Tarn, Cumberland! Rydal Fell, Westmoreland! Near the side of Windermere, Lancashire! Cautley Spout, Cocket Moss near Giggleswick, Ogden Clough, and Arncliffe (with zygospores), W. Yorks! Mickle and Cronkley Fells, and bog near Widdale Beck, N. Yorks!

Wales.—At over 3000 ft. on Snowdon, Carnarvonshire!

Scotland.—General, but scarce; zygospores from near Dinnet, Aberdeen (*Roy & Bissett*).

Geogr. Distribution.—Germany. Austria. Norway.

21. **Staurastrum suborbiculare** W. & G. S. West.

(Pl. CXXV, figs. 3–5.)

Staurastrum orbiculare Ralfs forma? Roy & Biss. Scott. Desm. 1893, t. 4, f. 7.

St. suborbiculare W. & G. S. West, New and Int. Freshw. Alg. 1896, p. 158, t. 4, f. 48; Alga-fl. Yorks. 1901, p. 101.

Cells small, about as long as broad, very deeply constricted, sinus narrowly linear; semicells pyramidate-subsemicircular, basal angles slightly rounded, sides convex, apex narrow and faintly retuse. Vertical view triangular, angles rounded, sides almost straight (very slightly concave). Cell-wall minutely and densely punctate.

Zygospore globose, densely covered with small conical verrucæ, each of which bears a very short spine at its apex.

Length 35–44 μ; breadth 35–38 μ; breadth of isthmus 7·5–9·5 μ; diam. zygosp. with short spines 37·5–45 μ.

England.—Cam Fell, W. Yorks!

Scotland.—Glas Mhoel, Perth (with zygospores)!

This species is distinguished from *St. orbiculare* var. *Ralfsii* by the more depressed semicells, with retuse apices, and by the very different nature of the zygospore.

22. **Staurastrum retusum** Turn.

(Pl. CXXV, figs, 6, 7.)

Staurastrum retusum Turn. Freshw. Alg. E. India, 1893, p. 104, t. 13, f. 13; Nordst. Index Desm. 1896, p. 224.

St. retusum var. *punctulatum* Eichl. & Gutw. Nonn. spec. alg. nov. 1894, p. 174, t. 5, f. 45; W. & G. S. West, Freshw. Alg. Ceylon, 1902, p. 178; Freshw. Alg. Burma, 1907, p. 216, t. 15, f. 30–32.

Cells small, as long as broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells shortly pyramidate-trapeziform, angles a little rounded, lateral margins straight, convex, or concave, apex very slightly concave. Vertical view triangular, angles rounded, sides concave. Cell-wall finely punctate, punctulations much more pronounced at the angles.

Zygospore unknown.

Length 15·5–30 μ; breadth 15·5–30 μ; breadth of isthmus 3·6–10 μ.

Geogr. Distribution.—Poland. India. Ceylon. Burma.

We have mentioned on two previous occasions that the var. *punctulatum* should most probably be regarded as identical with the original form. All the tropical forms of this species which have been found since the publication of Turner's description are punctulate, and Turner himself, judging by his expression "glabræ ?", was doubtful concerning this point. It should also be remembered that the figure given by Turner is from an old drawing of Wallich's, and is probably far from good.

The typical form of this species is not known to occur in the British Islands.

Var. **boreale** W. & G. S. West. (Pl. CXXV, fig. 8.)

St. retusum var. *boreale* W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25, t. 2, f. 30.

Cells smaller; semicells more rounded, lateral margins convex, apices very slightly retuse; cell-wall smooth.

Length 17·5–19 μ; breadth 16·2–17·5 μ; breadth of isthmus 5·5 μ.

Scotland.—Hoy, Orkneys! In bog near Lerwick, Shetlands!

23. **Staurastrum Cosmarioides** Nordst.

(Pl. CXXV, figs. 11, 12.)

Staurastrum Cosmarioides Nordst. Desm. Brasil. 1870, p. 223, t. 4, f. 43; Alg. Brasil. 1877, p. 23; De Toni, Syll. Alg. 1889, p. 1194; Börg. Desm. Brasil. 1890, pp. 49, 50, f. 1–6 [formæ]; W. & G. S. West, Some Desm. U. S. 1898, p. 313; Alga-fl. Yorks. 1901, p. 103.

Cells of various magnitudes, generally of medium size or rather large, about twice as long as broad, deeply constricted, sinus linear; semicells semi-elliptic, or subpyramidate, sides convex (rarely faintly concave in the middle), apex a little flattened and slightly thickened. Vertical view trigonal (or rarely tetragonal), with broadly rounded angles and very faintly retuse sides. Cell-wall punctate.

Zygospore unknown.

Length 64–142 μ; breadth 39–62 μ; breadth of isthmus 14–34 μ.

England.—Blubberhouses, W. Yorks (*W. B. Turner*). New Forest, Hants!

Scotland.—Ben Chiurn, Perth!

Geogr. Distribution.—United States. Guiana (var.). Brazil.

A number of somewhat varied forms have been figured by Börgesen as examples of this species. It is possible that all the records of *St. Cosmarioides* refer to trigonal and tetragonal forms of species of *Cosmarium* akin to *C. pyramidatum* and *C. pseudopyramidatum*, but further investigations are necessary to decide this point. *St. Cosmarioides* is one of those connecting-links between the genera *Cosmarium* and *Staurastrum*, and without doubt originated in the former genus. In parts of the American continent it appears to have become well established.

24. **Staurastrum tortum** (Lagerh. & Nordst.) *nob.*

(Pl. CXXV, fig. 9.)

Cosmarium tortum Lagerh. & Nordst. in Wittr., Nordst., & Lagerh. Alg. Exsic. 1903, no. 1486; fasc. 35, p. 16, f. 1–8.

Cells very small, a little longer than broad, conspicuously twisted at the isthmus, slightly constricted,

sinus scarcely evident; semicells obtrapeziform, with the sides slightly convex, apex truncate or sometimes widely concave, apical angles obtuse and almost imperceptibly produced. Side view of semicell semi-elliptic. Vertical view elliptic, with the semicells not in the same vertical plane. Cell-wall smooth.

Zygospore unknown.

Length 16–20 μ; breadth 14–17 μ; breadth of isthmus 10–11 μ; thickness 10·5 μ.

Wales.—In boggy pools, Glyder Fach, Carnarvonshire!

Geogr. Distribution.—Sweden.

We think this minute Desmid is better regarded as a *Staurastrum* than as a *Cosmarium* although it is obviously one of those peculiar species which connect the two genera. A marked twisting of the cell at the isthmus is a feature much more often met with in *Staurastrum* than in *Cosmarium*.

An Australian form of this species observed abundantly in the plankton of the Yan Yean Reservoir, Victoria, was trigonal in vertical view. The occurrence of this trigonal form (forma *trigona* G. S. West in 'Journ. Bot.' xliii, 1905, p. 253; 'Alg. Yan Yean,' 1909, p. 60, t. 5, f. 3, 4) adds weight to the suggestion that the species is best placed under the genus *Staurastrum*. It has not been seen in the British Islands, but we give a figure of it for comparison with the typical elliptic form (Pl. CXXV, fig. 10).

25. **Staurastrum subpygmæum** West.

(Pl. CXXV, figs. 13–16.)

Staurastrum subpygmæum West, Alg. W. Ireland, 1892, p. 178, t. 23, f. 8; W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 11, t. 2, f. 43 forma *glabra*; Alg. S. England, 1897, p. 494; Further Contrib. Freshw. Plankton Scott. Lochs, 1905, p. 486; Comp. Study Plankton Irish Lakes, 1906, p. 86; Brit. Freshw. Phytoplankton, etc., 1909, p. 183.

Cells of medium size, about as long as broad, deeply constricted, sinus subrectangular with an acuminate extremity; semicells very widely cuneate, lateral margins and apex convex, each lateral angle produced into a hollow mamilla. Vertical view triangular, with convex sides and mamillate angles. Cell-wall punctate (or rarely smooth).

Zygospore unknown.

Length 42–53 μ; breadth 39·5–52 μ; breadth of isthmus 16–22·5 μ.

England.—Borrowdale, Cumberland! Thursley Common, Surrey!

Scotland.—Plankton of Loch Luichart, Ross! Plankton of Loch Fadaghoda, Lewis, Outer Hebrides!

Ireland.—Lough Aunierin, and plankton of small lakes between Clifden and Roundstone, Galway!

St. subpygmæum is a well-marked species with an unfortunate name, as it bears no relationship to "*St. pygmæum*." We have never seen it in great abundance, although it has been frequent in some of the plankton-collections. It is a stout *Staurastrum*, its general convexity and mamillate angles giving it at once a distinctive character. The cell-wall is usually distinctly punctate, but in some individuals the punctulations are so faint as almost to escape detection, and in a few cases the cell-wall has appeared to be quite smooth. To the latter forms we gave the name of "forma *glabra*."

Some specimens of this species develop a wide gelatinous integument which may reach a diameter of 75 μ.

Var. **subangulatum** *var. nov.* (Pl. CXXIV, fig. 1.)

Cells somewhat smaller than in the type, and more deeply constricted; semicells subrhomboid-elliptic, angles less produced and thicker.

Length 41 μ; breadth 41 μ; breadth of isthmus 9·5 μ.

Scotland.—Loch Luichart, Ross!

26. **Staurastrum corniculatum** Lund.

(Pl. CXXV, figs. 17, 18.)

Staurastrum corniculatum Lund. Desm. Suec. 1871, p. 57, t. 3, f. 23; De Toni, Syll. Alg. 1889, p. 1150; Roy & Biss. Scott. Desm. 1893, p. 180; W. & G. S. West, Alg. S. England, 1897, p. 493; G. S. West, Alg. Yan Yean, 1909, pp. 15, 27.

Cells rather under medium size, $1\frac{1}{5}$–$1\frac{1}{4}$ times longer than broad, slightly constricted, sinus a small obtuse notch; semicells widely subcuneate, gradually widened from a broad base, sides very slightly convex (almost straight), apex straight, superior angles obliquely and

upwardly produced, obtuse. Vertical view triangular, with straight sides, angles obtusely rounded, sometimes a little produced. Cell-wall smooth.

Zygospore unknown.

Length 29–42 μ; breadth 28–33 μ; breadth of isthmus 12–17 μ.

England.—New Forest, Hants!

Scotland.—Bottomend and Heughhead near Aboyne, Aberdeen (*Roy & Bissett*).

Geogr. Distribution.—Sweden. Servia. Australia. New Zealand (var.). United States.

In 1896 we described and figured what we then regarded as the zygospore of *St. corniculatum* (*vide* W. & G. S. West, 'New and Int. Freshw. Alg.' 1896, p. 157, t. 4, f. 37; 'Alg. S. England,' 1897, p. 493). Subsequent investigation showed the zygospore to belong to *St. trachytithophorum*, a species of whose existence at that time we were unaware.

St. corniculatum is a very rare Desmid, but the following variety, although rare, appears to be widely distributed.

Var. **spinigerum** West. (Pl. CXXV, figs. 19–22.)

St. corniculatum var. *spinigerum* West, Alg. W. Ireland, 1892, p. 171, t. 22, f. 12; W. & G. S. West, Alg. N. Ireland, 1902, p. 45, t. 2, f. 22 [forma minor]; G. S. West, Alg. Yan Yean, 1909, pp. 15, 27.

Cells smaller, sometimes proportionately a little longer, angles of semicells produced to a variable degree and each furnished with a minute spine.

Length (without spines) 21–28 μ; breadth 15–25 μ; breadth of isthmus 9·5–11·5 μ; length of spines 1·5–1·7 μ.

Scotland.—Rhiconich, Sutherland! Harris, Outer Hebrides!

Ireland.—Lough Anna, Donegal (*forma minor*)! Lakes between Clifden and Roundstone, Galway!

Geogr. Distribution.—Australia.

Another variety of *St. corniculatum* described by Nordstedt from New Zealand as "var. *variabile*" (cf. Nordst. 'Freshw. Alg. N. Zeal.' 1888, p. 39, t. 4, f. 17), sometimes possesses a minute spine at one or more of the angles, which are also more acute.

Section D.

Cells furnished with small granules, generally covering the whole cell-wall, and regularly or irregularly disposed.

* Granules few and restricted to the angles which are produced (submamillate).

27. *St. trachytithophorum.*

** Granules more or less evenly distributed all over the cells.

† Semicells pyramidate-truncate.

28. *St. botrophilum.*

†† Semicells elliptic with broadly rounded angles.

‡ Sinus open. 29. *St. turgescens.*

‡‡ Sinus closed and linear; semicells elliptic-pyramidate.

30. *St. Donardense.*

††† Semicells oblong-elliptic, angles more or less produced and often subtruncate, apex flattened.

31. *St. alternans.*
32. *St. dilatatum.*
33. *St. disputatum.*
34. *St. striolatum.*
35. *St. rugulosum.*

†††† Semicells angularly elliptic (often rhomboid-elliptic), with a strongly convex apex.

‡ Angles rounded or broadly rounded, destitute of a mucro.

36. *St. punctulatum.*
37. *St. dispar.*
38. *St. pilosellum.*

‡‡ Angles slightly rounded, furnished with a mucro.

39. *St. granulosum.*
40. *St. paxilliferum.*

††††† Semicells angularly rotund (subcircular).

41. *St. inflatum.*

27. **Staurastrum trachytithophorum** W. & G. S. West.

(Pl. CXXVI, figs. 1, 2.)

Staurastrum trachytithophorum W. & G. S. West, Alg. S. England, 1897, p. 493, t. 6, f. 22.

Cells small, about as long as broad, deeply constricted, sinus open and subrectangular, with an acuminate extremity; semicells very widely cuneate,

lateral margins slightly convex, apex strongly convex, lateral angles upwardly turned and markedly mamillate, each mamilla with two ill-defined rings of minute granules, few granules in each ring. Vertical view triangular, sides very faintly convex, angles slightly produced and submamillate, with two rings of minute granules.

Zygospore globose, furnished with long, slender spines, the apices of which are deeply 2–4-furcate, with the divisions widely spreading.

Length 30–34 μ; breadth 29–32·5 μ; breadth of isthmus 10·5–11·5 μ; diam. zygosp. without spines 31 μ, with spines 63 μ; length of spines 15–19 μ.

England.—Thursley Common, Surrey (with zygospore)!

Only one zygospore of this species has been observed and it was at first referred to *St. corniculatum* Lund. (cf. W. & G. S. West, 'New and Int. Freshw. Alg.' 1896, p. 157, t. 4, f. 37). At that time the existence of *St. trachytithophorum* was not known, and we failed to notice the granules on the mamillate angles of the semicells still attached to the zygospore. The discovery of vegetative cells of *St. trachytithophorum* led to the re-examination of the supposed zygospore of *St. corniculatum*, when it was at once seen that old semicells did not belong to that species but were those of *St. trachytithophorum*.

28. **Staurastrum botrophilum** Wolle.

(Pl. CXXVI, fig. 4.)

Staurastrum botrophilum Wolle in Bull. Torr. Bot. Club, 1881, p. 2, t. 6, f. 13; Wolle, Desm. U. S. 1884, p. 131, t. 42, f. 11, 12 figures poor; fig. 13 ?; De Toni, Syll. Alg. 1889, p. 1170; Roy & Biss. Scott. Desm. 1893, p. 18 (sep.); W. & G. S. West, Some N. Amer. Desm. 1896, p. 261; Cushman in Rhodora, vii, 1905, p. 262.

Cells of medium size, $1\frac{1}{5}$–$1\frac{1}{4}$ times as long as broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity; semicells pyramidate-truncate, angles a little rounded, sides subconvex, apex truncate and straight. Vertical view triangular, sides faintly retuse in the middle, angles acutely rounded

Cell-wall granulate, granules arranged in concentric series around the angles, in the middle of the apex slightly reduced in size.

Zygospore unknown.

Length 46–50 μ; breadth 34–40·5 μ; breadth of isthmus 9–11 μ.

Scotland.—At 3500 ft. on Cairngorm, Inverness (*Roy & Bissett*).

Geogr. Distribution.—United States. Macedonia (?).

St. botrophilum is a very characteristic species, very rare in the British Islands, but more frequently observed in the United States. The figure we give (Pl. CXXVI, fig. 4) is a drawing made from one of Wolle's original specimens which that author sent to us some years ago.

29. **Staurastrum turgescens** De Not.

(Pl. CXXVI, figs. 5, 6.)

Staurastrum turgescens De Not. Desm. Ital 1867, p. 51, t. 4, f. 43; Arch. in Quart. Journ. Micr. Sci. 1878, p. 105; Cooke, Brit. Desm. 1887, p. 189, t. 66, f. 4; De Toni, Syll. Alg. 1889, p. 1189; West, Alg. N. Wales, 1890, p. 294; Alg. W. Ireland, 1892, p. 178; Alg. Engl Lake Distr. 1892, p. 731; ? Schmidle, Beitr. Algenfl. Schwarzwald. u. Rheineb. 1893, p. 109, t. 5, f. 28; Roy & Biss. Scott. Desm. 1893, p. 26 (sep.); Nordst. Index Desm. 1896, p. 263; W. & G. S. West, Alg. S. England, 1897, p. 494; Alga-fl. Yorks. 1901, p. 102; Alg. N. Ireland, 1902, p. 50; G. S. West, West Indian Freshw. Alg. 1904, p. 286; Alg. Third Tanganyika Expedit. 1907, p. 125; Hustedt, Desm. et Bacill. aus Tirol, 1911, p. 337.

St. punctulatum Bréb. var. *turgescens* (De Not.) Rabenh. Flor. Europ. Alg. III, 1868, p. 208.

St. punctulatum Bréb. var. *subrugulosum* Racib. Nonn. Desm. Polon. 1885, p. 86, t. 12, f. 13.

Cells rather small, a little longer than broad, deeply constricted, sinus a little open and acute-angled; semi-cells elliptic or elliptic-oblong. Vertical view triangular (very rarely quadrangular), sides concave, angles broadly rounded. Cell-wall finely granulate, granules fairly dense but without definite disposition.

Zygospore compressed and smooth, circular in the broad view with 9–12 marginal undulations, in the narrow view oblong-elliptic.

Length 28–38·5 μ; breadth 25–32·5 μ; breadth of isthmus 10–12 μ.

England.—Buttermere, and Blea Tarn in Borrowdale, Cumberland! Near Ambleside, Westmoreland! Crimsworth Dean, W. Yorks! Wimbledon Common, Surrey!

Wales.—Bog above Capel Curig Lakes, Llyn Gwynant, Yr Orsedd, and Y Foel Fras, Carnarvonshire! Ffestiniog, Merioneth!

Scotland.—Ross, Inverness, Aberdeen, Kincardine, Forfar, Perth, and Wigtown (*Roy & Bissett*). Caithness!

Ireland.—Gortahork, Donegal! Cloonee Lough, Kerry! Dublin and Wicklow (*Archer*). Slieve Donard, Down (up to 2000 ft.)!

Geogr. Distribution.—Germany. Austria (Tyrol). Italy. Bornholm. Poland. Central Africa. West Indies.

St. turgescens is a somewhat uncommon species easily distinguished by the elliptic or elliptic-oblong semicells and the broadly-rounded angles. The granulation is dense, but the granules have no definite arrangement. It is probably most nearly related to *St. alternans*.

The chloroplasts, according to Archer, are axile, with a number of irregular, divergent lobes somewhat like those which are found in the genus *Cylindrocystis*.

Archer found the zygospore of this species in Ireland (Consult 'Q. J. Micr. Sci.' xviii, new series, 1878, pp. 105, 106). It is very like those of *St. dilatatum* and *St. striolatum*. He describes it as follows:—"circular, compressed (thus shaped like a round cushion); in the broad view the margin is undulate, undulations nine to twelve, smooth; in the narrow (edge) view the zygospore is oblong-elliptic, sides parallel and straight for a notable distance at the middle, then gradually merging into the broadly-rounded extremities, margin smooth; contents at maturity passing into a bright brownish-yellow colour. An inspection of a zygospore in an oblique position, or, better still, of an empty membrane, showed that the undulations at the circumference of the broad aspect were carried onwards over the front surface, and that the elevations converged towards the centre, and at the same time diminished inwards, so as to disappear ere they reached the centre, where the surface appeared flat."

The smallest recorded form of *St. turgescens* is from pools

near the shore of Lake Nyasa in Central Africa (Consult G. S. West, 'Alg. Third Tanganyika Expedit.' 1907, p. 125); this was named "forma minor"; length 28 μ; breadth 25 μ; breadth of isthmus 10 μ.

Var. **arcticum** Wille. (Pl. CXXVII, fig. 24.)

St. turgescens var. *arcticum* Wille. Ferskv. Alg. Nov. Semlj. 1879, p. 51, t. 13, f. 57; W. & G. S. West, Alga-fl. Yorks. 1901, p. 102.

Cells proportionately narrower, sinus a little more open; semicells very broadly elliptic (almost rotund-elliptic); sides of vertical view convex.

Length 45 μ; breadth 30 μ; breadth of isthmus 14 μ.

England.—Ogden Clough, W. Yorks!

Geogr. Distribution.—Nova Zembla.

30. **Staurastrum Donardense** W. & G. S. West. (Pl. CXXVI, fig. 7.)

Staurastrum Donardense W. & G. S. West, Alg. N. Ireland, 1902, p. 50, t. 2, f. 33.

Cells small, a little longer than broad, deeply constricted, sinus narrowly linear with a faintly dilated extremity; semicells elliptic-semicircular, basal angles broadly rounded, apex subtruncate in the middle. Vertical view triangular, angles broadly rounded, sides straight or very slightly concave. Cell-wall very minutely granulate, granules arranged in indistinct rings around the basal angles.

Zygospore unknown.

Length 25·5–27 μ; breadth 21–23 μ; breadth of isthmus 6·5–7·5 μ.

Ireland.—Slieve Donard (abundant at 1800 ft.) and Slievecommedagh (at 2000 ft.), Down!

This species occurred abundantly amongst numerous examples of *St. turgescens* in boggy pools on granitic rocks.

It should be compared with *St. smaragdinum* Turn. ('Freshw. Alg. of E. India,' 1893, p. 103, t. 13, f. 14) from which it differs in its more rounded semicells with flatter apices, its coarser granulation, its wider isthmus, and in the

more rounded angles and straighter sides of the vertical view. It can also be compared with *St. punctulatum* var. *muricatiforme* Schmidle (=*St. muricatiforme* Schmidle, 'Beitr. alp. Alg.,' 1896, p. 162, t. 16, f. 14, 15), from which it is distinguished by its smaller size, its deeper constriction and much narrower sinus, its more compressed and flattened semicells, and by the rounder angles and straighter sides of the vertical view.

31. **Staurastrum alternans** Bréb.

(Pl. CXXVI, figs. 8, 9.)

Staurastrum tricorne Ralfs. in Ann. Mag. Nat. Hist. 1845, p. 155, t. 11, f. 2 [not *St. tricorne* (Bréb.) Menegh.].

St. alternans Bréb. in Ralfs' Brit. Desm. 1848, p. 132, t. 21, f. 7; Arch. in Pritch. Infus. 1861, p. 741, t. 2, f. 16, 17; Delp. Desm. subalp. 1877, p. 47, t. 11, f. 39–42; Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 53; ? Wolle, Desm. U. S. 1884, p. 128, t. 41, f. 26–28; Cooke, Brit. Desm. 1887, p. 162, t. 54, f. 7 figures very poor; Hansg. Prodr. Algenfl. Böhm. 1888, p. 254; Boldt, Desm. Grönland, 1888, p. 37; De Toni, Syll. Alg. 1889, p. 1193; West, Alg. N. Wales, 1890, p. 294; Alg. W. Ireland, 1892, p. 180; Alg. Engl. Lake Distr. 1892, p. 732; Lütkem. Desm. Attersees, 1893, p. 567; Roy & Biss. Scott. Desm. 1893, p. 16 (sep.); ? Turn. Freshw. Alg. E. India, 1893, p. 105, t. 16, f. 6; Nordst. Index Desm. 1896, p. 41; W. & G. S. West, Alg. S. England, 1897, p. 494; Schmidle, Lappmark Süsswasseralgen, 1898, p. 58; W. & G. S. West, Alga-fl. Yorks. 1901, p. 101; Börg. Alg. Færoës, 1901, p. 230; W. & G. S. West, Alg. N. Ireland, 1902, p. 51; Hirn, Desm. Finland, 1903, p. 19; Larsen, Freshw. Alg. E. Greenland, 1904, p. 95; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Borge, Beiträge Alg. Schweden, 1906, p. 46; G. S. West, Alg. Third Tanganyika Expedit. 1907, p. 125; Alg. Yan Yean, 1909, p. 28; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 181.

Phycastrum trilobatum Kütz. Spec. Alg. 1849, p. 179.

P. Ralfsii Näg. Gatt. einzell. Alg. 1849, p. 125.

Didymidium (*Staurastrum*) *punctulatum* A *minus* γ *alternans* Reinsch, Algenfl. Frank. 1867, p. 160.

St. dilatatum b. *alternans* Rabenh. Flor. Europ. Alg. III, 1868, p. 207.

Cells small, as long as broad, twisted at the isthmus through 60°, deeply constricted, sinus open and acute-angled; semicells rather narrowly oblong-elliptic, lateral angles rounded, apex flattened in the middle (but convex if the cell is very slightly oblique). Vertical view triangular, angles of one semicell alternating with those of the other, sides concave, angles rounded. Cell-wall finely granulate, granules arranged in concentric rings around the angles, but scattered and somewhat reduced in the middle of the apex.

Zygospore globose, and "furnished with spines forked at the apex" (*Ralfs*).

Length 22–33 μ; breadth 21–31 μ; breadth of isthmus 7·5–9·5 μ.

England.—Cumberland! Westmoreland! (*Ralfs*). W., N., and E. Yorks! Leicestershire (*Roy*). Essex! Oxfordshire! Gloucestershire! Surrey (zygospores from Thursley Common)! Sussex! Kent! Hants! Devon! Cornwall!

Wales.—Llyn Padarn!, Moelfre!, Capel Curig! (*Cooke & Wills*), and Bettwys-y-Coed (*Roy*), Carnarvonshire. Llyn Coron, Anglesey! Dolgelly, Merioneth (*Ralfs*).

Scotland.—Sutherland!, Ross, Inverness, Aberdeen, Kincardine, Forfar, Perth!, Fife (*Roy & Bissett*). Cumbræ, Ayr! Lewis, Outer Hebrides! Plankton of Loch Asta, Shetlands!

Ireland. — Donegal! Mayo! Galway! Kerry! Dublin and Wicklow (*Archer*). Londonderry!

Geogr. Distribution.—France. Germany. Austria and Galicia. Servia. Italy. Norway (and Finmark). Sweden. Denmark. Bornholm. Finland. N. Russia. Faeroes. Iceland. Nova Zembla. Greenland. India. Siam. Australia. New Zealand. Central Africa. United States.

Staurastrum alternans is a characteristic species with a world-wide distribution. It is found in all parts of the British Islands, but is never common. When seen in exact front view the semicells are narrowly elliptic-oblong, although the slightest tilting to an oblique position at once causes a change in their form. This fact alone is sufficient to separate *St. alternans* from *St. punctulatum*, although there are other important differences, such as the proportionately shorter cells, less open sinus, more rounded angles, and more retuse sides in the vertical view.

Ralfs' figure of *St. alternans* is very poor, scarcely differing in any respect from his figure of *St. dilatatum* except that it is triangular in vertical view. We have given a copy of this figure (Pl. CXXVI, fig. 9), although it conveys little idea of the characters of the species.

The granules in this species are only definitely arranged

around the angles, those at the apices having no regular disposition. The alternation of the angles of one semicell with those of the other is of no specific importance, notwithstanding the fact that the specific name was based upon this character. Such alternation is common in *Staurastra* of this kind, and is frequently observed in *St. punctulatum* and *St. dilatatum*.

The zygospore has been described by Ralfs, but not figured. We are not sure, however, that the zygospore described by Ralfs belonged to *St. alternans*, as for many years Ralfs was greatly confused between this species and *St. hexacerum* (= *St. tricorne* Ralfs). We have ourselves once observed a zygospore (from Thursley Common, Surrey), but the specimen was lost in attempting to permanently mount it. Unfortunately this happened before a drawing had been made.

We regard *St. alternans* var. *coronatum* Schmidle (1895) as a variety of *St. punctulatum* Bréb.

Var. **pulchrum** Wille. (Pl. CXXVII, fig. 16.)

St. alternans var. *pulchrum* Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 53 t. 13, f. 66; Boldt, Siber. Chlorophy. 1885, p. 115; Desm. Grönland, 1888, p. 37; Roy & Biss. Scott. Desm. 1894, p. 16 (sep.)

Cells proportionately a little longer, with an obtuse sinus; lower lateral margins of semicells slightly concave, apex less convex.

Length 28·8–36 μ; breadth 22·8–33·6 μ; breadth of isthmus 7·2–12 μ.

Scotland.—Glen Garry near Dalnacardoch, Perth!

Geogr. Distribution.—Nova Zembla. Greenland. Siberia.

This variety approaches *St. punctulatum*, but differs in the sinus, the form of the semicells, and the blunter angles (especially in the vertical view).

32. **Staurastrum dilatatum** Ehrenb.

(Pl. CXXVI, figs. 10–15.)

Staurastrum dilatatum Ehrenb. Infus. 1838, p. 143, t. 10, f. xiii description and figures very poor]; Ralfs in Ann. Mag. Nat. Hist. xv, 1845, p. 156, t. 11, f. 5; Brit. Desm. 1848, p. 133, t. 21, f. 8 [figures not good]; Arch. in Pritch. Infus. 1861, p. 741; Rabenh. Flor. Europ. Alg. III, 1868, p. 207; Kirchn. Alg. Schles. 1878, p. 165; ? ? Wolle, Desm. U. S. 1884, p. 128, t. 52, f. 32, 33; Nordst. Desm. Grönland, 1885, p. 10; Cooke, Brit. Desm. 1887, p. 162, t. 54, f. 8 [figures bad]; Hansg. Prodr. Algenfl.

Böhm. 1888, p. 212; De Toni, Syll. Alg. 1889, p. 1193; West, Alg. N. Wales, 1890, p. 294; Gutw. Flor. Glon. Okolic Lwowa, 1891, p. 66; West, Alg. W. Ireland, 1892, p. 180; Alg. Engl. Lake Distr. 1892, p. 732; Lütkem. Desm. Attersees, 1893, p. 567; Roy & Biss. Scott. Desm. 1893, p. 237; 1894, t. 4, f. 4; Nordst. Index Desm. 1896, p. 109; W. & G. S. West, Welw. Afric. Freshw. Alg. 1897, p. 181; Alg. S. England, 1897, p. 494; Schmidle, Lappmark Süsswasseralgen, 1898, p. 58; Lütkem. Desm. Millstättersees, 1900, p. 21 (sep); W. & G. S. West, Alga-fl. Yorks. 1901, p. 101; Alg. N. Ireland, 1902, p. 51; Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Borge, Beiträge Alg. Schweden, 1906, p. 46; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 349; W. & G. S. West, Freshw. Alg. Burma, 1907, p. 214.

Goniocystis (*Staurastrum*) *dilatata* Hass. Brit. Freshw. Alg. 1845, p. 353, t. 85, f. 5.

Phycastrum dilatatum Kütz. Phycol. germ. 1845, p. 138.

Staurastrum dilatatum var. *obtusilobum* De Not. Desm. Ital. 1867, p. 53, t. 4, f. 47; Nordst. Freshw. Alg. N. Zeal. 1888, p. 41, t. 4, f. 19; West, Alg. W. Ireland, 1892, p. 180; Alg. S. England, 1897, p. 494; Lutkem. Desm. Millstättersees, 1900, p. 21 (sep.); W. & G. S. West, Alga-fl. Yorks. 1901, p. 101; Alg. N. Ireland, 1902, p. 51; Freshw. Alg. Ceylon, 1902, p. 177; Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Further Contrib. Plankton Scott. Lochs, 1905, p. 487; Comp. Study Plankton Irish Lakes, 1906, p. 86; Teodoresco, Matér. flor alg. Rouman. 1907, p. 185; G. S. West, Alg. Yan Yean, 1909, pp. 28, 38; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 182.

Cells small, about as long as broad or sometimes a little longer, deeply constricted, sinus widely open and minutely acuminate at the extremity; semicells elliptic-subfusiform, dorsal margin convex, ventral margin greatly inflated in the median part, so that the greater portion of the semicell is raised up on a smaller ventral piece, lateral angles rounded or rounded-truncate. Vertical view 3–5 (usually 4)-angular, angles of one semicell often alternating with those of the other, sides deeply concave, angles rounded or rounded-truncate. Cell-wall finely granulate, granules arranged in concentric rings around the angles, and in regular series between the angles, extreme apex smooth or with a few minute punctulations.

Zygospore (?) "somewhat barrel-shaped, with round ends, and has numerous raised bands, passing longitudinally round it, giving the end view an undulated appearance" (*Roy & Bissett*).

Length 21–46 μ; breadth 22–46 μ; breadth of isthmus 7·5–13 μ; diam. zygosp. 48 μ.

England. — Cumberland! Westmoreland, up to 2400 ft. on Helvellyn! (*Ralfs*). Lancashire! W., N.,

and E. Yorks! Bucks! Oxfordshire! Warwickshire (*Wills*). Gloucestershire (*Ralfs*). Surrey! Sussex (*Ralfs*). Kent (*Ralfs*). Hants! (*Roy*). Devon! Cornwall!

Wales.—Capel Curig!, Llyn Padarn!, Llyn Idwal!, Llyn Gwynant!, Llyn-y-cwm-ffynon!, near Dolbadarn Castle!, Bettwys-y-coed (*Roy*), Pen-y-gwryd (*Roy*), and Glyder Fawr (*Roy*), Carnarvonshire.

Scotland.—General: zygospore near Dinnet, Aberdeen (*Roy & Bissett*). Sutherland! Inverness! Lewis and Benbecula, Outer Hebrides! Scottish plankton generally! Plankton of Loch Beosetter in Bressay, Shetlands!

Ireland.—Donegal! Mayo (including Achill and Clare Islands)! Several lakes in Galway! Several lakes in Kerry (also in plankton)! Dublin and Wicklow (*Archer*). Louth! Down! Londonderry!

Geogr. Distribution.—France. Germany. Austria and Galicia. Hungary. Roumania. Servia. Macedonia. Italy. Portugal. Norway. Sweden. Denmark. Central and S. Russia. Greenland. Japan. India. Ceylon. Australia. New Zealand. Madagascar. Central Africa. Azores. United States. Brazil. Bolivia. Paraguay. Argentina.

Staurastrum dilatatum is most frequent in bogs and at the boggy margins of lakes, and in some of the western areas of the British Islands it is commonly found in association with *Cosmarium conspersum* var. *latum*, *C. tetraophthalmum*, *C. reniforme*, *C. subundulatum*, *Staurastrum teliferum*, and other Desmids.

Ralfs' figures are poor and do not give an adequate idea of the characters of the species. We find the semicells somewhat variable in outward form. They may be regularly elliptic-fusiform, but more often there is a more or less distinct ventral inflation. The regularity of the granulation, especially as seen in the vertical view, is one of the principal characters of the species. The angles were described and figured by Ralfs as truncate, in consequence of which De Notaris (1867) founded for the form with rounded angles the var. *obtusilobum*. This form was admirably figured by Nordstedt in 1888, and since that date has been repeatedly

recorded by many authors, ourselves included, as a distinct variety. Careful examination of large numbers of specimens has convinced us, however, that the angles of this species are never more than subtruncate, and that every state exists between those which are subtruncate and those which are entirely rounded. We are therefore compelled to discard the var. *obtusilobum*, as it is founded upon a character which can only be regarded as slight, indefinite, and arbitrary.

The description given by Roy and Bissett of the zygospore requires confirmation. From their figure (in 'Ann. Scott Nat. Hist.' 1894, t. 4, f. 4) we should say that it is very similar to the zygospore of the closely allied species *St. striolatum*, in which case it would be compressed and not "barrel-shaped." The outlines of the semicells as depicted by Messrs. Roy and Bissett do not agree with those of *St. dilatatum*.

Cushman (in 'Bull. Torr. Bot. Club,' xxxii, 1905, p. 227, t. 8, f. 14) has also described and figured what he considers to be the zygospore of *St. dilatatum*. His description states that it is "elliptical, covered with rounded protuberances," and his figure, although somewhat poor, might possibly be reconciled with an oblique view of a zygospore similar to that of *St. striolatum* (cf. Pl. CXXVII, fig. 5).

The Desmid described by Boldt ('Desm. Grönland,' 1888, p. 37, t. 2, f. 48) under the name of "*St. margaritaceum* var. *truncatum*" is a variety of *St. dilatatum* with truncate apices, and should be placed as *St. dilatatum* var. TRUNCATUM.

Var. **hibernicum** *nob.* (Pl. CXXVI, fig. 18.)

St. sinense Lütkem. var. *hibernicum* W. & G. S. West, Alg. N. Ireland, 1902, p. 52, t. 2, f. 34.

Cells rather small, basal portion of semicells more pronounced; granules very minute, disposed in series around the angles but irregularly scattered on the rest of the cell.

Length 24 μ; breadth 21–24 μ; breadth of isthmus 7 μ.

IRELAND.—Lough Anna, Donegal!

This Desmid was originally described as a variety of *St. sinense*, but the convex apex of the semicells, combined with the fact that the cell is finely granulate all over, points unmistakably to a close relationship with *St. dilatatum*.

33. **Staurastrum disputatum** *nov. nom.*

(Pl. CXXVI, fig. 16; Pl. CXXIX, fig. 1.)

St. dilatatum var. *insigne* Racib. Desmidyja Ciastonia, 1892, p. 388, t. 1, f. 13; W. & G. S. West, Welw. Afric. Freshw. Alg. 1897, p. 181 [forma minor]; Borge, Alg. erst. Regnell. Exped., II. Desmid. 1903, p. 107, t. 4, f. 12 [forma minor].

Cells small, a little longer than broad, moderately constricted, sinus widely open and obtuse-angled, with the apex minutely acuminate; semicells widely cuneiform from a broad base, lateral margins slightly retuse, apex widely truncate and flat, angles slightly produced and rounded. Vertical view quadrangular, angles somewhat produced and rounded, sides concave. Cell-wall granulate at the angles, but the body of the cell (including the apices) quite smooth, granules disposed in 4 or 5 rings around the angles.

Zygospore unknown.

Length 35 μ; breadth 33 μ; breadth of isthmus 19 μ.

Ireland.—Near Westport, Mayo! Lough Bofin, Galway!

Geogr. Distribution.—W. Africa. Brazil. Argentina.

It does not seem to us quite correct to place this Desmid as a variety of *St. dilatatum*. It differs from that species very much in the form of its semicells and in its granulation. The sinus is more widely open, the apex of the semicell is very widely truncate and straight, and the granules are confined to the angles, around which they are disposed in four or five series. Under these circumstances we have established it as a species. Neither "*insigne*" nor "*Raciborskii*" could be utilized for the specific name, as both are already in use.

Borge has mentioned a "forma *minor*" from Brazil: length 20–21 μ; breadth 20–21 μ; breadth of isthmus 9 μ. We recorded this same small form from West Africa in 1897.

The following might also be best regarded as varieties of this species:—

Var. sinense (Lütkem.) nob. *St. sinense* Lütkem. Desm. Central China, 1900, p. 124, t. 6, f. 39, 40; G. S. West, Alg. Third Tanganyika Expedit. 1907, p. 125. Cells smaller, body

of semicells somewhat smaller, angles more produced and cylindrical (almost forming cylindrical processes), with about four rings of minute granules. Length 18–20 μ; breadth 18–23 μ; breadth of isthmus 7 μ. (Pl. CXXVI, fig. 19). *Distrib.*—Central China. Central Africa.

Var. EXTENSUM (Borge) nob. *St. dilatatum* Ehrenb. var. *extensum* Borge, Beiträge Alg. Schweden, 1906, p. 46, t. 3, f. 37. Basal portion of semicells narrower and almost shortly cylindrical, causing the angles to appear more produced; granules arranged in 5 or 6 rings around each angle. Length 23–24 μ; breadth 19·5 μ; breadth of isthmus 6·5 μ. (Pl. CXXVI, fig. 17). *Distrib.*—Sweden.

We have given figures of both the above varieties in order to render clearer the characters of *St. disputatum*. *The broad, flat apex, and the restriction of the granules to the circles around the angles, are its distinctive features.*

St. moniliferum Playfair ('New or Less-known Desm. N. S. Wales,' 1907, p. 188, t. 5, f. 7) and *St. campanulatum* Playfair (l.c. p. 189, t. 5, f. 8) may both be forms of this Desmid but at present they are insufficiently known.

34. **Staurastrum striolatum** (Näg.) Arch.

(Pl. CXXVII, figs. 1–5.)

Phycastrum (*Amblyactinium*) *striolatum* Näg. Gatt. einzell. Alg. 1849, p. 126, t. 8 A, fig. 3.

Staurastrum striolatum (Näg.) Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 201; Nordst. Desm. Brasil. 1870, p. 225, t. 4, f. 45; Wittr. Gotl. Öl. sötv. Alg. 1872, p. 52; Kirchn. Alg. Schles. 1878, p. 164; ? Wolle, Desm. U. S. 1884, p. 126, t. 51, f. 27, 28; Lagerh. Bidr. Amerik. Desm.-fl. 1885, p. 245; Cooke, Brit. Desm. 1887, p. 158, t. 54, f. 4 [figures poor]; De Toni, Syll. Alg. 1889, p. 1188; West, Alg. W. Ireland, 1892, p. 178; Nordst. Index Desm. 1896, p. 243; Cushman, in Bull. Torr. Bot. Club, 1905, p. 552; in Rhodora, 1905, p. 264; Borge, Beiträge Alg. Schweden, 1906, p. 43; G. S. West, Alg. Yan Yean, 1909, pp. 38, 69, t. 6, f. 10–12.

St. striolatum var. *ælandicum* Wittr. Gotl. Öl. sötv. Alg. 1872, p. 52.

St. striolatum forma *brasiliensis* Turn Freshw. Alg. E. India, 1893, p. 109, t. 13, f. 15 [figures poor]; W. & G. S. West, Some Desm. U. S. 1898, p. 313.

St. dilatatum var. *indicum* Turn. l. c. t. 13, f. 17 [figure poor].

Cells small, about as long as broad; deeply constricted, sinus widely open, rather obtuse at the extremity; semicells somewhat oblong-elliptic, dorsal margin (apex) straight or slightly retuse, ventral margin convex and inflated in the middle, lateral angles rounded or subtruncate. Vertical view triangular, sides concave, angles rounded or subtruncate.

Cell-wall finely granulate, granules arranged in rings around the angles, although sometimes a little scattered on the body of the semicell, granules at the end of each angle often a little larger than the rest.

Zygospore compressed, having a circular outline in the front view, with 10–12 marginal undulations; side view oblong.

Length 19–28 μ; breadth 18–28 μ; breadth of isthmus 6–10 μ; diam. zygosp. 35–39 μ, thickness 21–24 μ.

Wales.—Capel Curig and near Bethesda, Carnarvonshire!

Ireland.—Near Westport, Louisburgh, and Dugort, Mayo! Near Leenane, Roundstone, and Ballynahinch, Galway!

Geogr. Distribution.—Germany. Galicia in Austria. Hungary. Norway. Sweden. India. Australia. New Zealand. Azores. United States. Brazil. Patagonia.

St. striolatum differs from *St. dilatatum* in the outward form of its semicells and its somewhat different granulation. As in *St. disputatum* the semicells have a flat apex, but the granulation extends over the whole body of the *Staurastrum*.

We can see no valid reason for the separation of Wittrock's var. *ælandicum*, the characters of which were based upon the zygospore. This is, however, similar in every respect to other zygospores which must be attributed to *St. striolatum*.

We figure the following variety for comparison with the more typical forms of *St. striolatum*:—

Var. divergens nob. [*St. alternans* var. *divergens* W. & G. S. West, Freshw. Alg. Ceylon, 1902, p. 177, t. 21, f. 18.] Cells a little smaller, apices of semicells concave, angles very faintly dilated (indistinctly subcapitate) and slightly divergent; angles of one semicell alternating with those of the other. Length 17 μ; breadth 17–18 μ; breadth of isthmus 5·5 μ. (Pl. CXXVII, fig. 6.) *Distrib.*—Ceylon.

35. **Staurastrum rugulosum** Bréb.

(Pl. CXXVI, fig. 3.)

Staurastrum rugulosum Bréb. in Ralfs' Brit. Desm. 1848, p. 214, t. 35, f. 19; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 208; Kirchn. Alg. Schles. 1878, p. 164; De Toni, Syll.

Alg. 1889, p. 1170; ? Heimerl, Desm. alpin. 1891, p. 605; Roy & Biss. Scott. Desm. 1893, p. 241; Lagerh. Chlor. Abessin. u. Kordofan, 1893, p. 163; Schmidle, Lappmark Süsswasseralgen, 1898, p. 54; Gutw. Flor. Alg. Mont. Tatr. 1909, p. 471.

Cells small, a little broader than long, deeply constricted, sinus slightly open, narrowly acute-angled; semicells oblong-elliptic, with a rather flattened apex. Vertical view triangular, sides very slightly concave, angles rounded. Cell-wall granulate, granules somewhat irregularly scattered and a little more prominent at the angles.

Zygospore unknown.

Length 33 μ; breadth 36 μ; breadth of isthmus 13 μ.

Scotland.—Near Strathpeffer, Ross; Cairnmonearn, Kincardine (*Roy & Bissett*).

Geogr. Distribution.—France. Germany. Sweden. Galicia in Austria. Madagascar (forma ?). Abyssinia.

We regard this species as exceedingly doubtful. The figure in Ralfs' 'British Desmids,' of which we give a copy, is very poor, and the original description is much too brief. Gutwinski, Heimerl, Roy, Lagerheim, and Schmidle are the only authors who have recorded it since its description in 1848, and Heimerl's measurements (length 38–49 μ; breadth 37–44 μ) are considerably larger than those obtained by measuring Ralfs' original figure. Wolle's supposed figures of this Desmid ('Desm. U. S.' 1884, t. 41, f. 41, 42) are too uncertain to be of any value.

It is possible that *St. rugulosum* is merely a form of *St. alternans*, but the available evidence is insufficient to make a definite statement regarding its exact position.

We have ourselves recorded what we believed to be a form of *St. rugulosum* from Madagascar (cf. W. & G. S. West, 'Alg. Madag.' 1895, p. 74), but we are not at all certain of the correct position of this form.

36. **Staurastrum punctulatum** Bréb.

(Pl. CXXVII, figs. 8–11, 13, 14.)

Staurastrum punctulatum Bréb. in Ralfs' Brit. Desm. 1848, p. 133, t. 22, f. 1; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 208; Lund. Desm. Suec. 1871, p. 63; ? Nordst. Desm. Spetsb. 1872, p. 39; Norges Desm. 1873, p. 29; Desm. Arctoæ, 1875, p. 34; Kirchn. Alg. Schles. 1878, p. 164; Gay, Monogr. loc. Conj. Montpellier, 1884, p. 66; ? Wolle, Desm. U. S. 1884, p. 127, t. 41, f. 43–45; Nordst. Desmid. Grönland, 1885, p. 10; Cooke, Brit. Desm. 1887,

p. 160, t. 54, f. 6; Hansg. Prodr. Algenfl. Böhm. 1888, pp. 212, 251; Boldt, Desm. Grönland, 1888, p. 34; De Toni, Syll. Alg. 1889, p. 1190; West, Alg. N. Yorks, 1889, p. 293; Alg. N. Wales, 1890, p. 294; Heimerl. Desm. alpin. 1891, p. 605; West, Alg. W. Ireland, 1892, p. 179; Alg. Engl. Lake Distr. 1892, p. 732; Borge, Chlorophy. Norska Finmark. 1892, p. 7; Gutw. Flor. glonów Galic. 1892, p. 134; Lütkem Desm. Attersees. 1893, p. 566; Roy & Biss. Scott. Desm. 1894, p. 24 (sep.); Nordst. Index Desmid. 1896, p. 213; Schmidle, Beitr. alp. Alg. 1896, p. 62; W. & G. S. West, Welw. Afric. Freshw. Alg. 1897, p. 181; Alg. S. England, 1897, p. 494; Alga-fl. Yorks. 1901, p. 101; Börg. Freshw. Alg. Færoës, 1901, p. 230; Bohlin, Flor. Algol. d'eau douce d. Açores, 1901, p. 61, t. 1, f. 20, 21; W. & G. S. West, Alg. N. Ireland, 1902, p. 50; Hirn, Desm. Finland, 1903, p. 22; W. & G. S. West, Scott. Freshw. Plankton, I. 1903, p. 529; Larsen, Freshw. Alg. E. Greenland, 1904, p. 99; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Borge, Beiträge Alg. Schweden, 1906, p. 45; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 184; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 352; W. & G. S. West, Freshw. Alg. Burma, 1907, p. 214; G. S. West, Alg. Yan Yean, 1909, p. 28; W. & G. S. West, Brit. Freshw. Phytoplankton, etc., 1909, p. 183; Phytoplankton Engl. Lake Distr. 1909, p. 139; Hustedt, Desm. et Bacill. aus Tirol, 1911, p. 337.

Didymidium (*Staurastrum*) *punctulatum* Reinsch, Algenfl. Frank. 1867, p. 159.

Staurastrum punctulatum forma *contorta* Schmidle, Beitr. alp. Alg. 1896, p. 62.

Cells small, a little longer than broad, deeply constricted, often twisted at the isthmus, sinus open and acute-angled (about 70°); semicells subrhomboid-elliptic, dorsal and ventral margins about equally convex, angles somewhat acutely rounded. Vertical view triangular (rarely 4-, and very rarely 5-angular), angles acutely rounded, sides slightly retuse in the middle; angles of one semicell often partly or entirely alternating with those of the other. Cell-wall uniformly granulate with *flattened* granules, which are in regular series around the angles.

Zygospore globose, furnished with rather short spines which are doubly furcate at the apex, each one arising from a broadly mamillate base.

Length 26–40·5 μ; breadth 23–36·5 μ; breadth of isthmus 8–16 μ; diam. zygosp. without spines 29–38 μ, with spines 42–58 μ.

England. — Cumberland! Westmoreland! Lancashire! W., N., and E. Yorks. (zygospores from Keighley, W. Yorks)! Leicester (*Roy*). Essex! Cambridge! Warwicks! (*Wills*). Worcestershire! Staffordshire! Middlesex! Surrey (zygospores from

Devil's Jumps near Frensham)! Sussex (*Ralfs*). Kent! Hants! (*Roy*). Devon! Cornwall (zygospores from Tremethick Moor)! (*Marquand*).

Wales.—Fairly general!

Scotland.—General, but rather scarce! (*Roy & Bissett.*) Loch More, Sutherland! Loch Doon, Ayr! Dumfries! Wigtown! Plankton of Orkneys and Shetlands! Rather rare in general plankton!

Ireland.—Donegal! Mayo (and Clare Island)! Galway! Kerry! Dublin and Wicklow (*Archer*). Down (up to 2000 ft.)! Lough Neagh, Antrim! Londonderry!

Geogr. Distribution.—France. Germany. Switzerland. Austria and Galicia. Hungary. Servia. Roumania. Italy. Spain. Norway (and Finmark). Sweden. Denmark. Bornholm. Finland. Poland. Russian Lapland. N., Central, and S. Russia. Faeroes. Iceland. Nova Zembla. Spitzbergen. Greenland. Japan. E. India. Ceylon. Java. Australia. New Zealand. Azores. United States. Brazil. Argentina. Patagonia (a form).

St. punctulatum is one of the most ubiquitous species of the genus, being almost universally distributed in bogs, marshes, and marshy pools. Its characters are distinctive, although it is subject to considerable variation. The cells are frequently twisted at the isthmus, so that the angles of one semicell are not vertically over those of the other, and in many individuals the twist is fully 60°. The semicells are usually triangular in vertical view, but tetragonal forms are by no means rare. The granules are uniform in character and somewhat depressed, having a disposition in concentric series around the angles, but at the apex of the semicell, and in other parts, they are irregularly scattered. In its most typical form the semicells of *St. punctulatum* are on the whole rhomboid-elliptic, with acutely-rounded lateral angles, and the sides of the vertical view are slightly retuse in the middle.

Some of the specimens recorded by Nordstedt from within the arctic circle are larger than any British specimen we have yet seen: length up to 52 μ; breadth up to 48 μ.

The smallest forms we have seen were from Lewis, Outer Hebrides; length 22 μ; breadth 18·5 μ (Pl. CXXVII, fig. 12).

A careful consideration of the various forms of *St. punctulatum* and its allies has convinced us that *St. Kjellmani* Wille, *St. pygmæum* Bréb. and *St. punctulatum* all belong to the same species-group. We have found it clearly impossible to separate these Desmids as distinct species, as the intermediate forms constitute a gradation through which any line of demarcation is purely arbitrary. We have therefore placed all the various forms under the one species *St. punctulatum*.

We wish it to be understood that this closer grouping of the above "species," so often regarded as distinct, is an expression of opinion that after twenty years' experience of them from all parts of the world we are still unable to draw up valid specific characters.

St. subpunctulatum Gay ('Monogr. loc. Conj. Montpellier,' 1884, p. 66, t. 2, f. 8) is most probably only a form of *St. punctulatum*.

It is possible to discriminate between seven more or less distinct British varieties of *St. punctulatum*.

Var. **subproductum** *var. nov.* (Pl. CXXVII, fig. 15.)

Staurastrum punctulatum forma G. S. West, Alga-fl. Cambr. 1899, p. 219.

Cells proportionately wider, lateral angles of semicells very slightly produced; vertical view with faintly convex sides and almost imperceptibly produced angles.

Length 31 μ; breadth 31 μ; breadth of isthmus 8·5 μ.

England.—Dernford Fen, Cambridgeshire!

To this variety belongs the form described by Boldt from Greenland (*cf.* Boldt, 'Desmid. Grönland,' 1888, p. 35, t. 2, f. 43) as "forma semicellulis a vertice visis area triangulari nuda, lateribus in medio tumidis." This form has the faintly produced angles characteristic of var. *subproductum*, but in the middle of the apex of each semicell is a triangular smooth area.

Var. **Kjellmani** Wille. (Pl. CXXVII, figs. 13, 17–19, 21, 22.)

Staurastrum Kjellmani Wille, Ferskv. Alg. Nov. Semlj. 1879, p. 50, t. 13, f. 50–53 [forma trigona major, forma trigona minor, and forma tetragona]; Cooke, Brit. Desm. 1887, p. 163, t. 54, f. 9; West, Alg. N. Yorks. 1889, p. 293; Alg. W. Ireland, 1892, p. 177; Alg. Engl. Lake Distr. 1892, p. 731; Roy & Biss. Scott. Desm. 1894, p. 21 (sep.); Nordst. Index Desm. 1896, p. 152; W. & G. S. West, Alga-fl. Yorks. 1901, p. 102; Bohlin, Flor. Algol. d'eau douce d. Açores, 1901, p. 62; Larsen,

Freshw. Alg. E. Greenland, 1904, p. 97; G. S. West, Treat. Brit. Freshw. Alg. 1904, p. 139, f. 51 F; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25.

St. punctulatum var. *Kjellmani* Wille in Dijmphna-Togtets zool.-bot. Udbytte, 1886, p. 86; Boldt, Desm. Grönland, 1888, p. 35; De Toni, Syll. Alg. 1889, p. 1190; Börg. Ferskv. Alg. Östgrönl. 1894, p. 26; Schmidle, Lappmark Süsswasseralgen, 1899, p. 57; Börg. Freshw. Alg. Færoës, 1901, p. 230; Borge, Beiträge Alg. Schweden, 1906, p. 45; Teodoresco, Matér. flor. alg. Rouman. 1907, p. 185; Larsen, Ferskvandsalg. Vest.-Grönl. 1907, p. 353; Hustedt, Desm. et Bacill. aus Tirol, 1911, p. 337.

St. punctulatum as figured by W. & G. S. West, Notes Alg. II, 1900, p. 297, t. 412, f. 13 [zygosp.]

St. Bieneanum Rabenh. forma *groenlandica* Larsen, Freshw. Alg. E. Greenland, 1904, p. 96.

Cells with a more open sinus (almost rectangular), angles of semicells more rounded; sides of vertical view straight or slightly convex; granulation on the whole a little finer and denser.

Zygospore similar to that of type, but with the spines a little stouter.

Length 30–48 μ; breadth 24–37·5 μ; breadth of isthmus 9–20 μ; diam. zygosp. without spines 29 μ, with spines 42 μ.

England.—Blea Tarn in Borrowdale, Cumberland! Near Bowness (*Bissett*), Helvellyn, Stickle Tarn, and Blea Tarn, Westmoreland! Wrynose, Lancashire! Mickle Fell, N. Yorks! Darenth Wood, Kent (with zygospore)!

Wales.—Glyder Fawr (at 2700 ft.), Snowdon (at over 3000 ft.), Carnarvonshire!

Scotland. — General on the higher mountains! (*Roy & Bissett.*) Up to 3500 ft. on Lochnagar, Aberdeen! Shetlands!

Ireland.—Lough Guitane and Carrantuohill, Kerry! Glengariff, Cork!

Geogr. Distribution.—Germany. Austria and Galicia. Roumania. Norway. Sweden. Faeroes. Nova Zembla. Spitzbergen. Greenland. Azores (var.)

In making a comparative examination of numerous forms from various localities we find it impossible to separate *St. Kjellmani* from *St. punctulatum*, and we have therefore adopted Wille's decision of 1886 and placed it as a variety of

that species. It is essentially an alpine and arctic variety, and often attains a larger size than the average specimens of the type.

The semicells are somewhat variable in shape, triangular and quadrangular forms being almost equally common. The bluntness of the angles and the rather finer granulation are the principal features of the variety.

We have observed one zygospore (Pl. CXXVII, fig. 13) which we figured in 1900 as that of *St. punctulatum* (Cf. W. & G. S. West, 'Notes Alg II,' t. 412, f. 13).

Var. **coronatum** (Schmidle) *nob.*

St. alternans var. *coronatum* Schmidle, Weitr. Beitr. Algenfl. Rheineb. u. Schwarzwald, 1895, p. 82, t. 1, f. 21; Schröder, Alg. Versuchsteiche Schles. Fischereiv. Trachenberg, 1897, p. 42.

Semicells with six rounded warts of small size in the central part of the apex, one opposite each side and each angle.

Length 28 μ; breadth 22 μ.

Ireland.—Achill Island, Mayo! Near Roundstone, Galway!

Geogr. Distribution.—Germany.

This variety has the proportions and also the acutely rounded and slightly inflated angles of *St. punctulatum*. The apical warts are very distinctive.

Var. **pygmæum** (Bréb.) *nob.* (Pl. CXXVIII, figs. 1, 2.)

Staurastrum pygmæum Bréb. in Ralfs' Brit. Desm. 1848, p. 213, t. 35, f. 26 [description and figure very poor]; Arch. in Pritch. Infus. 1861, p. 740; Rabenh. Flor. Europ. Alg. III, 1868, p. 220; Wittr. Gotl. Öl. sötv. Alg. 1872, p. 53, t. 4, f. 10; Cooke, Brit. Desm. 1887, p. 157, t. 54, f. 1 [figures poor]; Hansg. Prodr. Algenfl. Böhm. 1888, p. 213; De Toni, Syll. Alg. 1889, p. 1181; West, Alg. N. Wales, 1890, p. 293; Alg. W. Ireland, 1892, p. 177; Alg. Engl. Lake Distr. 1892, p. 731; Lütkem. Desm. Attersees, 1893, p. 565; Roy & Biss. Scott. Desm. 1894, p. 24 (sep.); Börg. Ferskv. Alg. Östgrönl. 1894, p. 26; Nordst. Index Desm. 1896, p. 214; W. & G. S. West, Alg. S. England, 1897, p. 494; Schmidle, Lappmark Süsswasseralgen, 1898, p. 56; W. & G. S. West, Alga-fl. Yorks. 1901, p. 102 [in part]; Börg. Freshw. Alg. Færöes, 1901, p. 230; W. & G. S. West, Alg. N. Ireland, 1902, p. 50; Hirn, Desm. Finland, 1903, p. 23; Cushman in Rhodora, v, 1903, p. 222; in Bull. Torr. Bot. Club, xxxii, 1905, p. 552; W. & G. S. West, Freshw. Alg. Orkneys and Shetlands, 1905, p. 25; Borge, Beiträge Alg. Schweden, 1906, p. 45; Larsen, Ferskvandsalg. Vest-Grönl. 1907, p. 353.

Cells with a slightly broader isthmus; sides of vertical view convex, straight, or slightly concave; granules minute but *acute*.

Zygospore similar to that of type, but with slightly longer spines.

Length 27–42 μ; breadth 24–40 μ; breadth of isthmus 9–18 μ.

England. — Cumberland! Westmoreland! Lancashire! W., N., and E. Yorks! Surrey! Devon! Cornwall!

Wales.—Fairly general in Carnarvonshire!

Scotland.—Sutherland! Ross, Aberdeen, Kincardine, Forfar, Perth! (*Roy & Bissett.*) Renfrew! Wigtown! Orkneys and Shetlands!

Ireland. — Donegal! Mayo (and Clare Island)! Galway! Kerry! Down (up to 2000 ft.)!

Geogr. Distribution.—France. Germany. Austria and Galicia. Portugal. Norway. Sweden. Bornholm. Finland. Poland. N. Russia. Faeroes. Nova Zembla. Spitzbergen. Greenland. Siberia. Sumatra. Madagascar (var.). E. Africa. United States. Brazil. Ecuador.

There is only one reliable distinction between this variety and typical *St. punctulatum*, and that is in the nature of the granulation. The granules of var. *pygmæum* are sharp, whereas those of the type are flattened or rounded. The isthmus of the cells is also, as a rule, a trifle broader. There is no difference in the shape of the semicells, except in vertical view, in which the sides are generally straight or slightly convex. This difference is, however, of little importance, as in many specimens the sides of the vertical view are concave (consult Pl. CXXVIII, fig. 2 *b*). Sometimes the cells are of exactly the same outward form as those of typical *St. punctulatum*, but the granules are sharp (Pl. CXXVIII, figs. 3 and 9). Such forms belong to the var. *pygmæum* only by reason of their sharp granules.

One form, which so far has only been observed from Nacoogarrow Lough in Galway, has three series of slightly larger granules forming a triangle on the apex of each semicell; length 48 μ; breadth 40 μ; breadth of isthmus 15 μ (Pl. CXXVIII, fig. 4). It should be known as forma TRILINEATA

[= *St. pygmæum* var. *trilineatum* West, 'Alg. W. Ireland,' 1892, p. 177, t. 23, f. 7].

"*St. pygmæum* var. *obtusum*" Wille ('Ferskv. Alg. Nov. Semlj.' 1879, t. 13, f. 56) appears to be more closely related to *St. hexacerum* (Ehrenb.) Wittr.

Var. **striatum** *var. nov.* (Pl. CXXVIII, figs. 5, 6.)

St. pygmæum as figured by W. & G. S. West, Notes Alg. II, 1900, p. 297, t. 412, f. 12.

Semicells more distinctly rhomboid than in the type; granules most minute, fewer in number, and arranged in somewhat distant series around the angles. Zygospore exactly like that of var. *pygmæum*.

Length 29–31 μ; breadth 29–31·5 μ; breadth of isthmus 9·5–11·5 μ; diam. zygosp. without spines 36–37 μ, with spines about 67 μ.

England.—Cautley Spout, W. Yorks (with zygospores)!

This is the most angular of any of the varieties of *St. punctulatum*. It is well characterized by its somewhat distant lines of granulations.

Two other forms of *St. punctulatum*, although not yet found in the British Islands, require brief mention.

Forma elliptica Lewin, Span. Süsswasseralg. 1888, p. 9, t. 1, f. 16. Semicells rather narrowly elliptic; length 24·6–26·6 μ; breadth 25·2–29·3 μ; breadth of isthmus 8·7–9·3 μ. *Distrib.* Spain. We have seen nothing precisely like this form, and think that it may possibly belong to *St. alternans*.

Var. muricatiforme Schmidle, Lappmark Süsswasseralgen, 1898, p. 57 [= *St. muricatiforme* Schmidle, Beitr. alp. Alg. 1895, t. 16, f. 14, 15; 1896, p. 162]. Cells with a less open sinus; semicells elliptic-subsemicircular, granulation less dense than in the type; angles in the vertical view more rounded. Length 28–32 μ; breadth 23–30 μ. Schmidle has described a "forma *lapponica*" of this variety which very nearly approaches *St. punctulatum* f. *elliptica* Lewin. We have not observed var. *muricatiforme* from any part of the British Islands, and as originally described by Schmidle it appears to be known only from the Tyrol.

37. **Staurastrum dispar** Bréb.

Staurastrum dispar Bréb. Liste Desm. 1856, p. 144, t. 1, f. 27; Nordst. Freshw. Alg. N. Zeal. 1888, p. 41; Roy & Biss. Scott. Desm. 1893, p. 237.
Phycastrum dispar (Bréb.) Grogn. Plant. cryptogam.-cellul. du departm. de Saone-et-Loire, Autun, 1863, p. 262.

Cells small, about as long as broad, very deeply constricted, sinus open and acute-angled; semicells narrowly elliptic-rhomboid or elliptic fusiform, dorsal margin somewhat more convex than the ventral margin, lateral angles acutely rounded. Vertical view triangular, angles subacute, those of one semicell alternating with those of the other, sides convex. Cell-wall finely granulate, granules arranged in concentric rings around the angles.

Zygospore . . . . . ?

Length 27·5 μ; breadth 27–28 μ.

England. — Delamere, Cheshire (*Roy*). Leicester (*Roy*). Enbridge Lake, Hants (*Roy*).

Wales.— Capel Curig, Carnarvonshire (*Roy*).

Scotland.—Sutherland, Ross, Aberdeen (zygospores from Slewdrum), Kincardine, Forfar, Perth, Dumbarton (*Roy & Bissett*).

Geogr. Distribution.—France. Norway. Sweden. New Zealand.

This species is recorded by Roy from several English counties and one Welsh one, also by Roy and Bissett from several Scottish counties; they also report the zygospores from Slewdrum in Aberdeen, but give neither description nor figure of them. We have not seen anything exactly corresponding to Brébisson's original figure, but the following Irish form should most probably be referred to *St. dispar*:—

Forma. (Pl. CXXVII, fig. 7.) Angles of semicells truncate-emarginate; vertical view with slightly concave sides. Length 24μ; breadth 23–24μ; breadth of isthmus 6μ. Cf. W. & G. S. West, 'Alg. N. Ireland,' 1902, p. 52, t. 2, f. 30.

Ireland.—Lough Gartan, Donegal.

38. **Staurastrum pilosellum** *sp. nov.*

(Pl. CXXVIII, figs. 7, 8.)

Cells small, about $1\frac{1}{4}$ times as long as broad, deeply constricted, sinus open and rectangular; semicells

broadly subrhomboid-elliptic, ventral margin somewhat more convex than dorsal margin, lateral angles rounded. Vertical view triangular, sides straight, angles broadly rounded. Cell-wall granulate, granules with no definite disposition, and those at the angles modified to form minute spines, with a smooth area at the apex of each semicell.

Zygospore globose, furnished with long spines, each arising from a broadly conical base, and doubly furcate at the apex.

Length 34–35 μ; breadth 27–29 μ; breadth of isthmus 10–12·5 μ; diam. zygosp. without spines 38 μ, with spines 63–67 μ.

England.—Near St. Just, Cornwall (with zygospores)!

This species appears to connect the *St. punctulatum* species-group with those forms possessing minute spines such as occur in *Staurastrum hirsutum*. The zygospore is exactly like those of *St. punctulatum* var. *pygmæum* and *St. punctulatum* var. *striatum*. The outward shape of the semicells and the form of the vertical view are more or less in agreement with *St. punctulatum* var. *Kjellmani*, but the character of the granulation is quite different, especially in the development of the minute spines at the angles.

39. **Staurastrum granulosum** (Ehrenb.) Ralfs. (Pl. CXXVIII, figs. 10–12.)

Desmidium granulosum Ehrenb. in Abh. Akad. Wiss. Berlin, 1839, pp. 51, 56, t. 1, f. 12.

Staurastrum granulosum (Ehrenb.) Ralfs, Brit. Desm. 1848, p. 217; Arch. in Pritch. Infus. 1861, p. 738; Rabenh. Flor. Europ. Alg. III, 1868, p. 206; De Toni, Syll. Alg. 1889, p. 1147; Gutw. Flor. glonów Galic. 1892, p. 134; ? Roy & Biss. Scott. Desm. 1893, p. 238; 1894, t. 3, f. 6; W. & G. S. West, Alg. N. Ireland, 1902, p. 45, t. 2, f. 24; Notes Alg. III, 1903, p. 76; Scott. Freshw. Plankton, I. 1903, p. 529; Freshw. Alg. Orkneys and Shetlands, 1905, p. 24; Comp. Study Plankton Irish Lakes, 1906, p. 86; Brit. Freshw. Phytoplankton, etc., 1909, p. 182.

St. lunatum Ralfs var. *subarmatum* W. & G. S. West, New Brit. Freshw. Alg. 1894, p. 10, t. 2, f. 47.

Cells small, about as long as broad, or sometimes a little longer, deeply constricted, sinus open and subrectangular, with an indistinctly acuminate apex; semicells more or less obsemicircular, apex convex,

lateral angles scarcely rounded, furnished with a mucro (or very minute spine). Vertical view triangular, median portion of sides retuse, angles acutely rounded and mucronate. Cell-wall granulate; granules minute and arranged in concentric rings around the angles, much reduced and scattered at each apex.

Zygospore globose, furnished with long slender spines, which are slightly furcate at the apex.

Length 29–33 μ; breadth (with mucro) 27–33 μ; breadth of isthmus 9–12·5 μ; diam. zygosp. without spines 32·5–34·5 μ, with spines 62–65 μ; length of spines 13·4–15·5 μ.

England.—Epping Forest, Essex! Near Crowan, Cornwall (with zygospores)!

Wales.—Capel Curig!, and Glyder Fawr (*Roy*), Carnarvonshire.

Scotland.—Rhiconich, Sutherland! Near Tain, Ross; Birsemore, Aberdeen; Cammie, Heughhead and Dalbrake (with zygospores) in Strachan, Kincardine (*Roy & Bissett*). Plankton of lakes in Lewis, N. Uist, and Benbecula, Outer Hebrides! Shetlands!

Ireland.—Loughs Cloncarney and Gartan, Donegal! Derryclare Lough, Galway! Plankton of Lough Neagh! Lough Fea and Plankton of L. Beg, Londonderry!

Geogr. Distribution.—France. Germany. Galicia in Austria.

St. granulosum is at once distinguished from all forms of *St. punctulatum* by the more flattened apices of the semicells and the mucronate angles. The cells are slightly variable in external form, due largely to differences in proportionate length and breadth.

We have previously mentioned ('Journ. Bot.' 1903, p. 76) that the figure of the zygospore given by Roy and Bissett is very indistinct and specifically unrecognizable.

Forma **connexa**. (Pl. CXXVIII, fig. 13.)

Angles of semicells furnished with a pair of minute spines in place of a single mucro.

Length 28·5 μ; breadth 25–27 μ; breadth of isthmus 9·5 μ.

Scotland.—Plankton of Loch Asta, Shetlands!

Ireland.—Plankton of Lough Neagh! Lough Gartan, Donegal!

In this form some or all of the angles are furnished with two minute spines. The form thus approaches the granulate forms of *St. Avicula*, and to a smaller extent it resembles *St. denticulatum*.

Var. **acutum** (Bréb.) W. & G. S. West. (Pl. CXXVIII, fig. 14.)

Staurastrum acutum Bréb. Liste Desm. 1856, p. 143, t. 1, f. 26; Rabenh. Flor. Europ. Alg. III, 1868, p. 202; Kirchn. Alg. Schles. 1878, p. 168; Roy & Biss. Scott. Desm. 1893, p. 178.

St. granulosum var. *acutum* (Bréb.) W. & G. S. West, Alg. N. Ireland, 1902, p. 45, t. 2, f. 25; Scott. Freshw. Plankton, I. 1903, p. 529; Brit. Freshw. Phytoplankton, etc., 1909, p. 182.

Semicells elliptic-fusiform, dorsal and ventral margins more equally convex; sides of vertical view straight.

Length 29–30 μ; breadth without mucro 28–31 μ, with mucro 30–33 μ; breadth of isthmus 11·5–12·5 μ.

Wales.—Capel Curig, Carnarvonshire (*Roy*).

Scotland.—Ross, Inverness, Aberdeen, Kincardine, Forfar, Perth (*Roy & Bissett*). Plankton of Loch Mhor Bharabhais in Lewis, Outer Hebrides!

Ireland.—Near Glenties, Donegal! Plankton of Lough Neagh! Plankton of Lower River Bann, Londonderry!

Geogr. Distribution.—France. Germany.

40. **Staurastrum paxilliferum** G. S. West. (Pl. CXXVIII, fig. 15.)

Staurastrum paxilliferum G. S. West, Alga-fl. Cambr. 1899, p. 219, t. 396, f. 8; W. & G. S. West, Alga-fl. Yorks. 1900, p. 100.

Cells somewhat small, a little longer than broad, deeply constricted, sinus open and subrectangular, with a submamillate apex; semicells subelliptic, ventral margin a little more convex than the dorsal margin, angles subacute and furnished with a prominent

but rounded mucro. Vertical view triangular, with straight sides and slightly rounded angles, each angle furnished with a rather blunt mucro. Cell-wall granulate, granules rather distant, those near the angles more or less papilliform and arranged in three concentric series, granules away from the angles much smaller, irregularly punctate between the granules, apices of semicells smooth.

Zygospore unknown.

Length 36·5–40 μ; breadth with mucros 32–38·5 μ; breadth of isthmus 12·5–13·5 μ.

England.—Pilmoor, N. Yorks! Wicken Fen, Cambridge!

This species should be compared with *St. granulosum* (Ehrenb.) Ralfs, with which it appears to have a very close affinity. It should also be compared with *St. brachyacanthum* Nordst.

41. **Staurastrum inflatum** sp. nov.

(Pl. CXXVII, fig. 23.)

Staurastrum Kjellmani Wille var. *rotundatum* W. & G. S. West, New and Int. Freshw. Alg. 1896, p. 158, t. 4, f. 46; Alga-fl. Yorks. 1901, p. 102 ["rotundum"].

Cells rather small, about $1\frac{2}{3}$ longer than broad, moderately constricted, sinus very widely open and obtuse-angled; semicells obovate-subcircular, the widest part being about two-thirds the height of the semicell. Vertical view quadrate-circular. Cell-wall densely granulate; granules fairly large with no definite disposition, a little smaller towards the isthmus.

Zygospore unknown.

Length 43 μ; breadth 25–26·5 μ; breadth of isthmus 13·5 μ.

Hab.—Ogden Clough, W. Yorks!

This species is at once distinguished from *St. punctulatum* var. *Kjellmani* by its proportionately greater length, its more open sinus, its much more rounded semicells, and its coarser granulation.

The name "rotundatum" is already in use for an Indian species of this genus.

EXPLANATION OF THE PLATES.

NOTE ON THE TEXT.

For reasons mentioned in the preceding volume (on p. 274) several species of *Cosmarium* which were there figured are described in the present volume.

EXPLANATION OF THE LETTERING.

a, *a'*, *a''*. Front view of cell or semicell.
b, *b'*. Vertical view.
c. Side view.
d. Basal view of semicell.

PLATE XCVI.

FIGS.		PAGE
1–2.—	*Cosmarium Botrytis* Menegh. × 500 .	1
3–4.—	*C. Botrytis* var. *paxillosporum* W. & G. S. West. 3, × 400; 4, zygospore, × 520 .	4
5–6.—	*C. Botrytis.* Two zygospores, × 520 .	2
7–15.—	Germination of zygospore of *C. Botrytis,* × 190 (after De Bary) . . .	3

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PLATE XCVII.

FIGS. PAGE

1.—*Cosmarium Botrytis* Menegh. var. *subtumidum* Wittr. × 400 (after Wittrock) . . 4

2–3.—*C. Botrytis* var. *tumidum* Wolle. × 500 . 5

4.—*C. Botrytis* var. *gemmiferum* (Bréb.) Nordst. × 500 6

5.—*C. Botrytis* var. *mediolæve* West. *a* and *b*, × 400; *a'*, × 500 6

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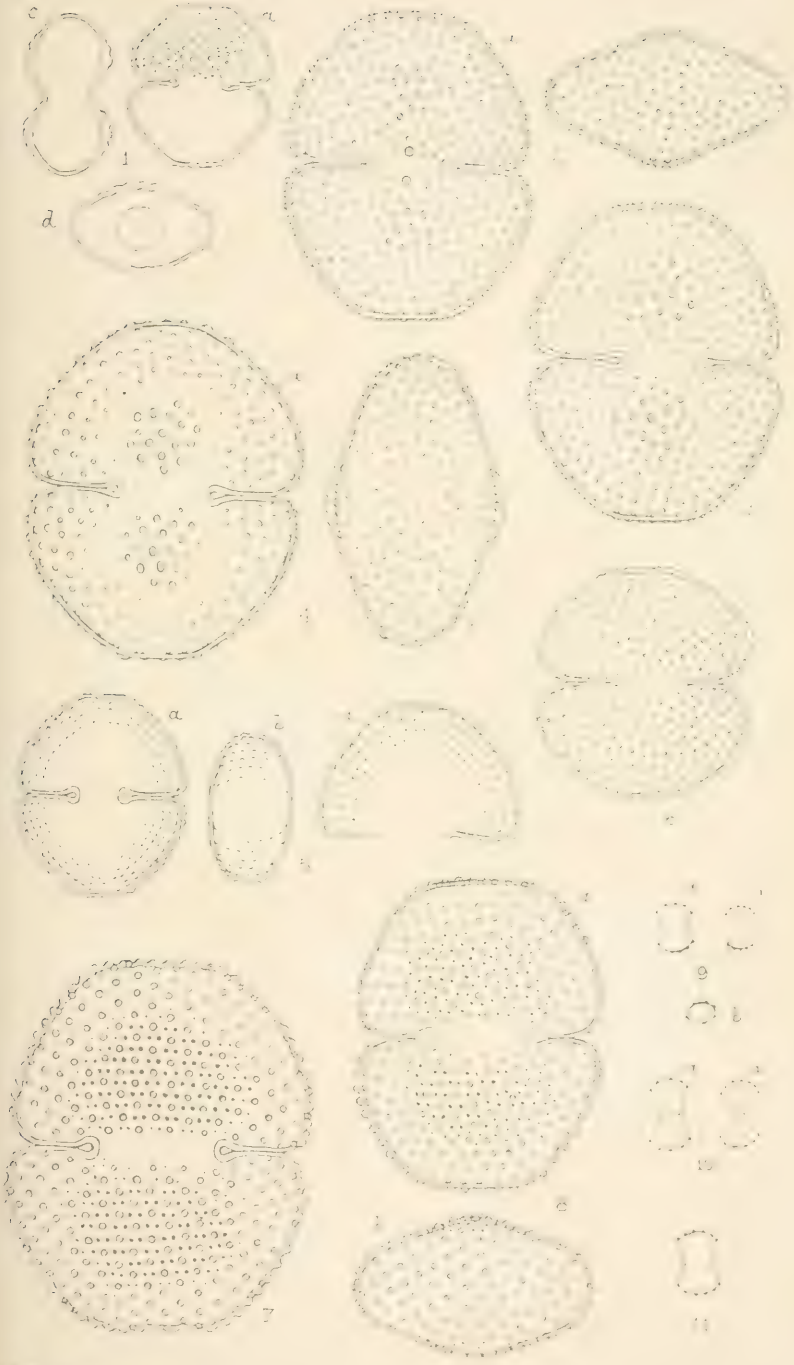
7–8.—*C. controversum* West. 7, × 520; 8, × 430 . 9

9–11.—*C. tuberculatum* Arch. 9 and 10, × 400 (after Archer); 11, × 400 . . . 42



G.S.West del

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PLATE XCVIII.

FIGS. PAGE

1–3.—*Cosmarium ochthodes* Nordst. 1, × 400 (after Nordstedt); 2, × 520; 3, zygospore, × 520 . 10

4–6.—*C. ochthodes* var. *amœbum* West. 4 and 6, × 520; 5, a few of the depressed, lobed granules, × 830 11

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15.—*C. crenatum* var. *bicrenatum* Nordst. × 570 (after Nordstedt) 38

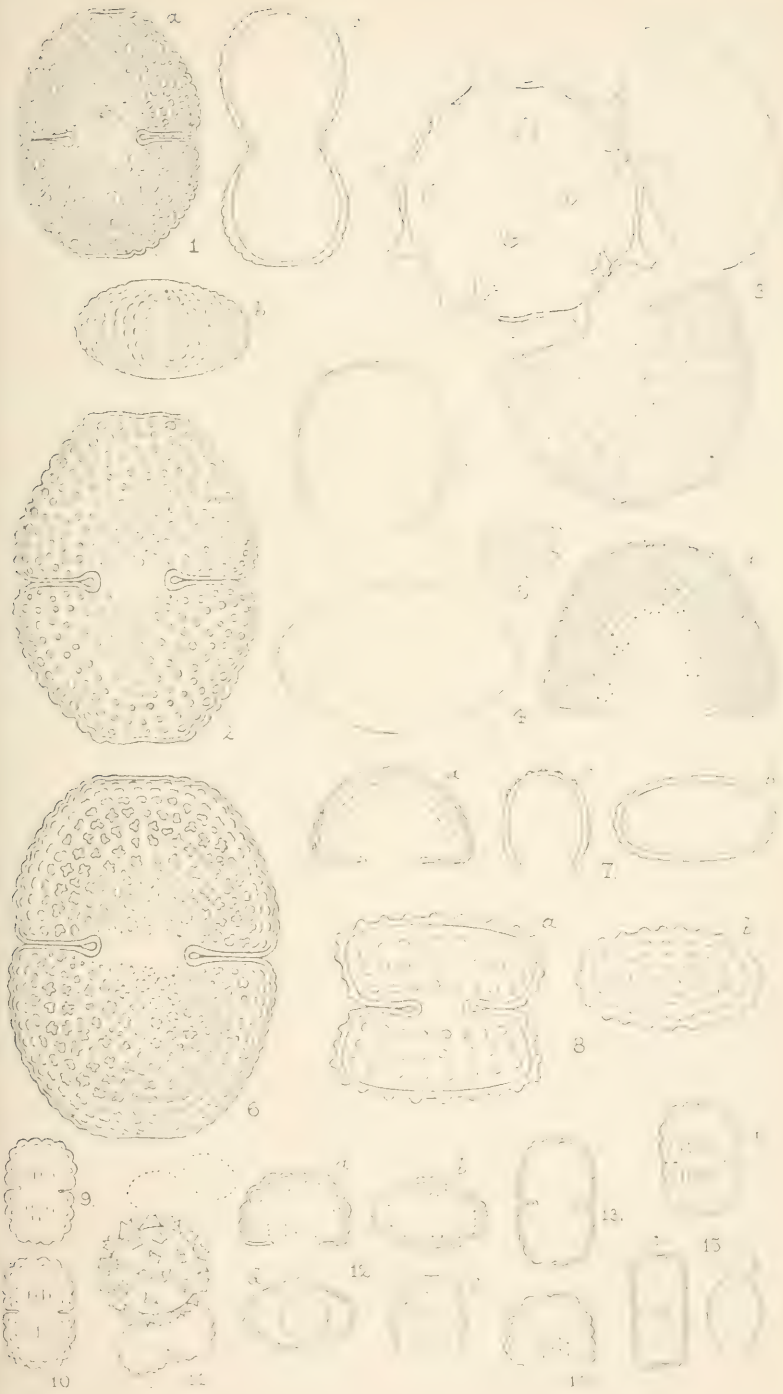
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Plate 99

PLATE XCIX.

FIGS. PAGE

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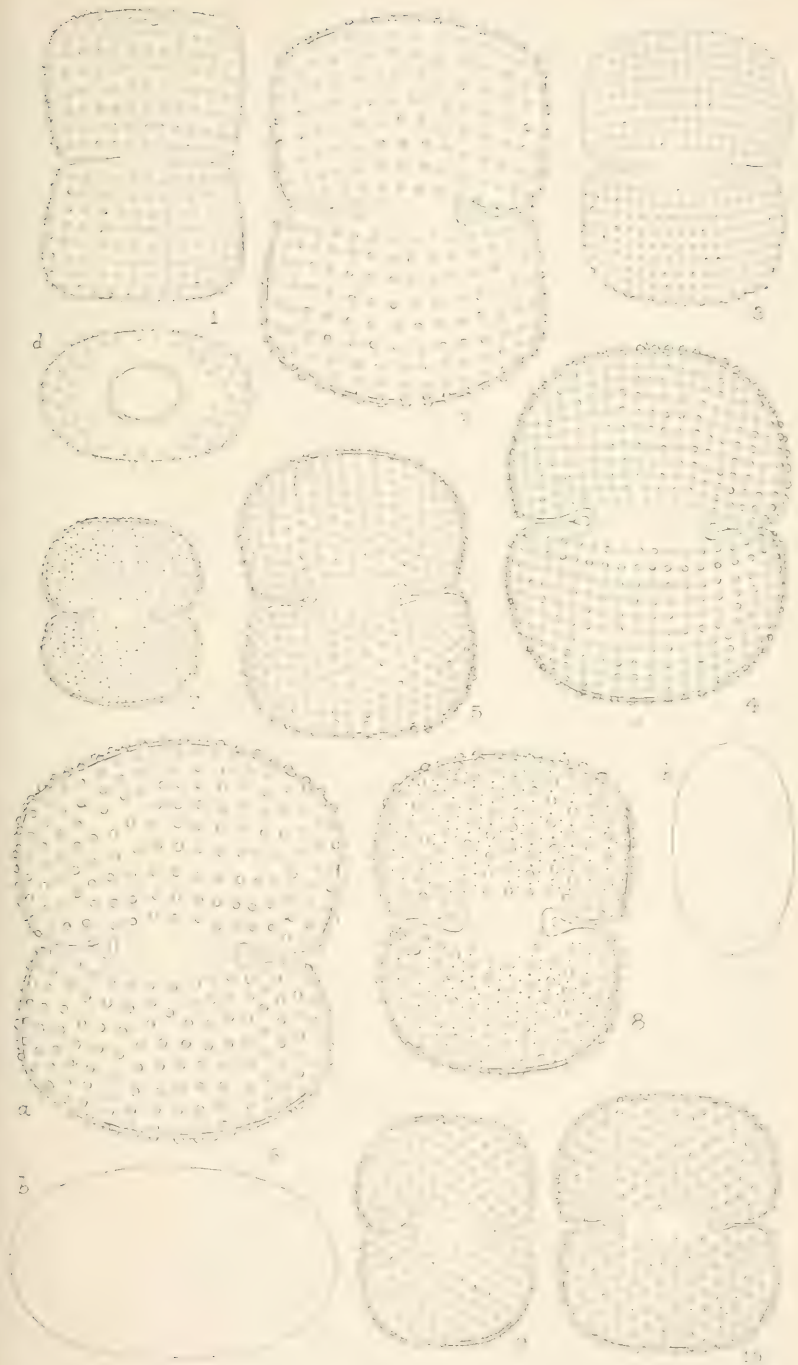
9.—*C. margaritatum* forma *minor* Boldt. × 520 . 19

10.—*C. margaritatum*. × 520 . . . 18



G.F.West del.

Plate 100

PLATE C.

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1.	—*Cosmarium margaritatum* (Lund.) Roy & Biss. forma *subrotundata* W. & G. S. West. × 500	19
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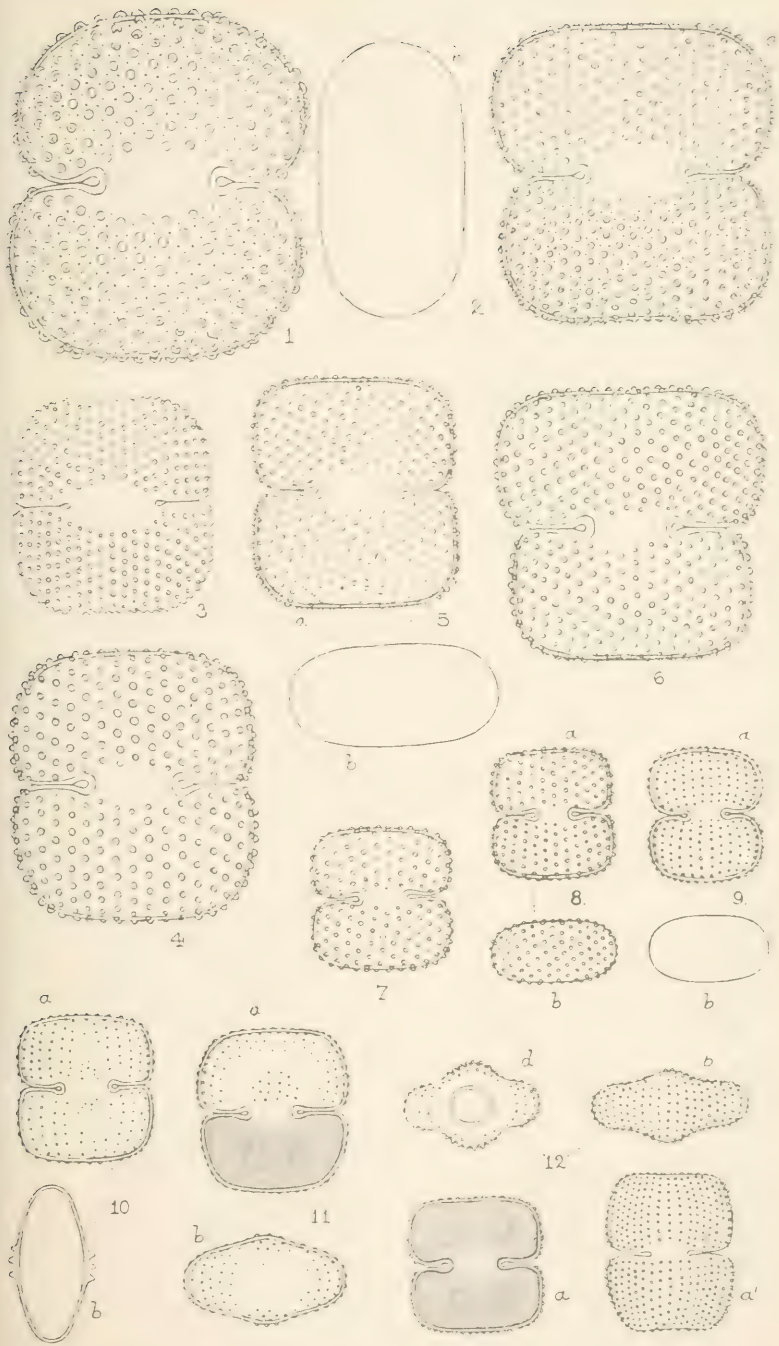

G.S.West del

Plate 101

PLATE CI.

FIGS. PAGE

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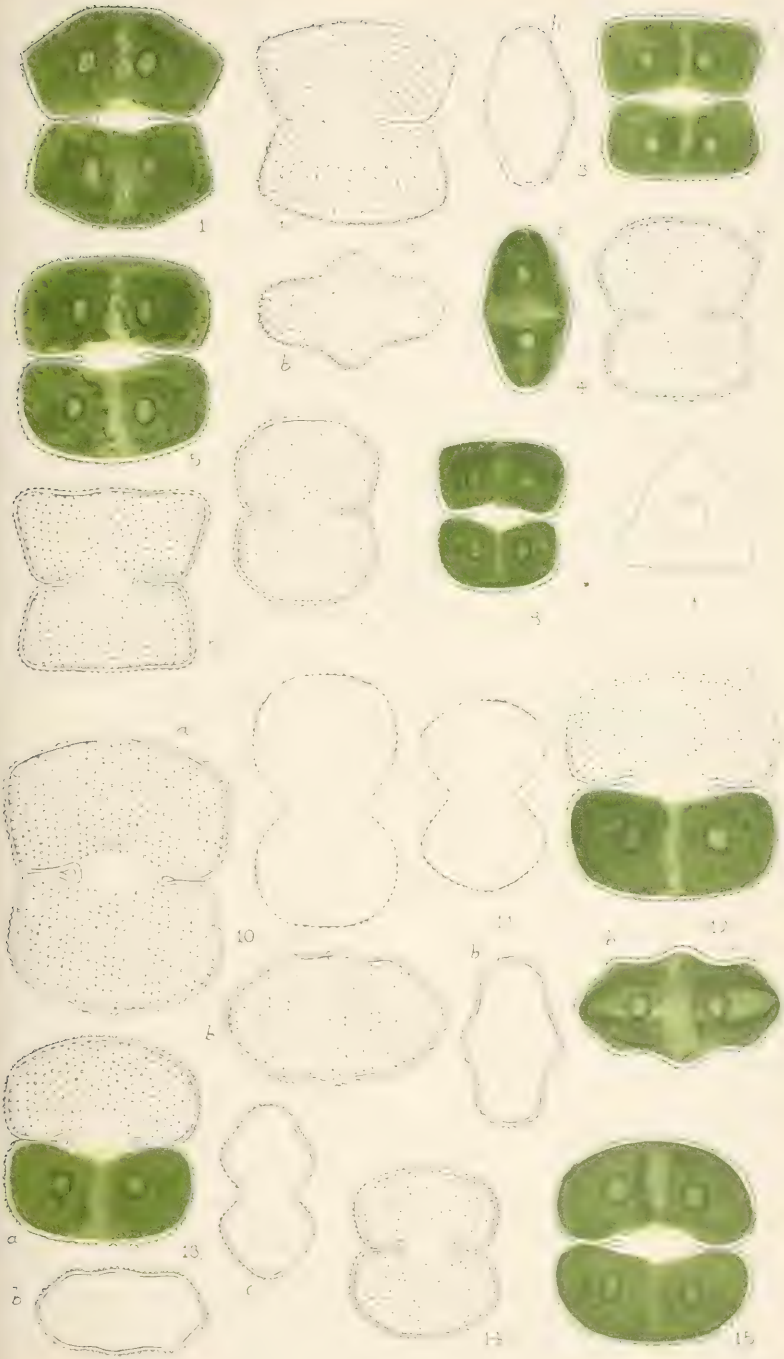

PLATE CII.

FIGS. PAGE

1–4.—*Cosmarium amœnum* Ralfs. 1 and 3, × 500; 2, × 520; 4, × 400 . . . 29

5–6.—*C. amœnum* var. *mediolæve* Nordst. 5, × 625; 6, × 570 (after Nordstedt) . . 31

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10–12.—*C. pseudamœnum* var. *basilare* Nordst. 10, × 570 (after Nordstedt); 11, × 520; 12, × 500 32

13–15.—*C. annulatum* (Näg.) De Bary. 13, × 600 (after Nägeli); 14, three individuals forming a short chain, × 400; 15, × 500 . . 39

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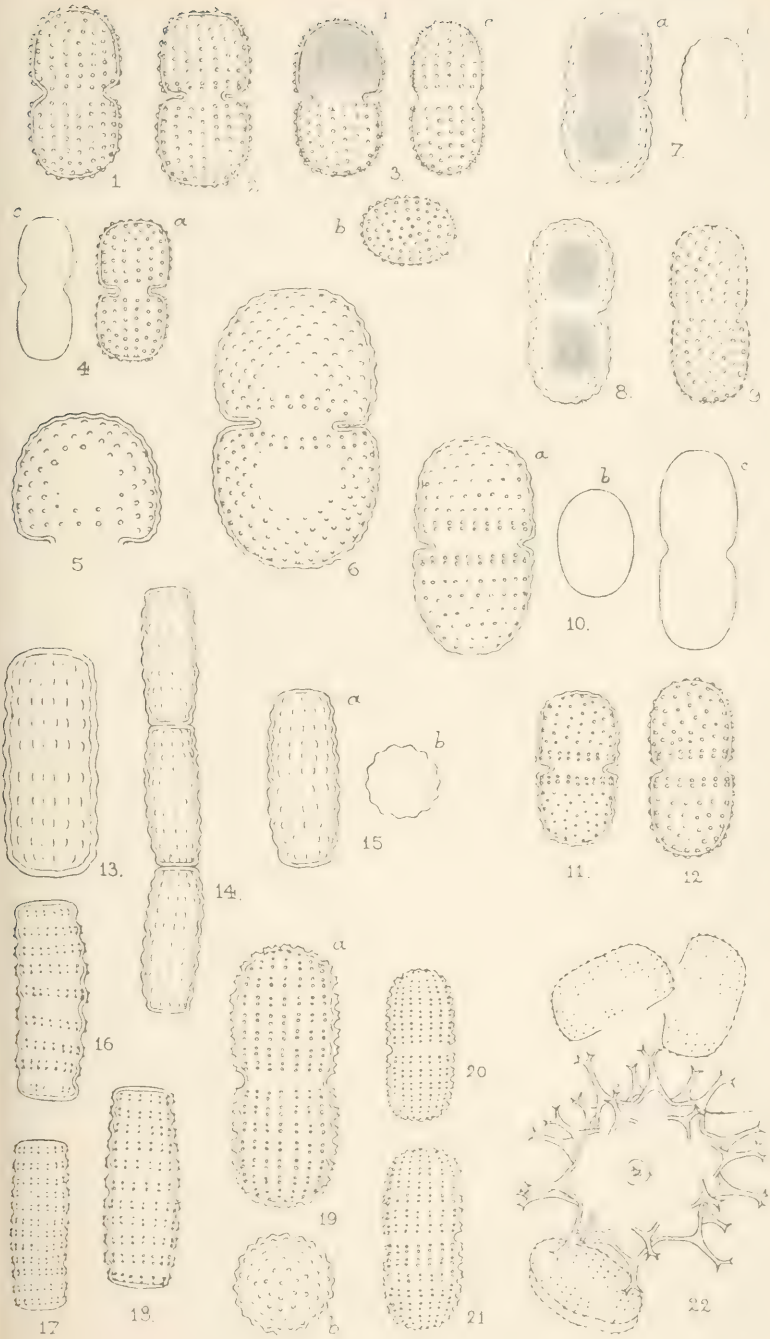

G.S.West del

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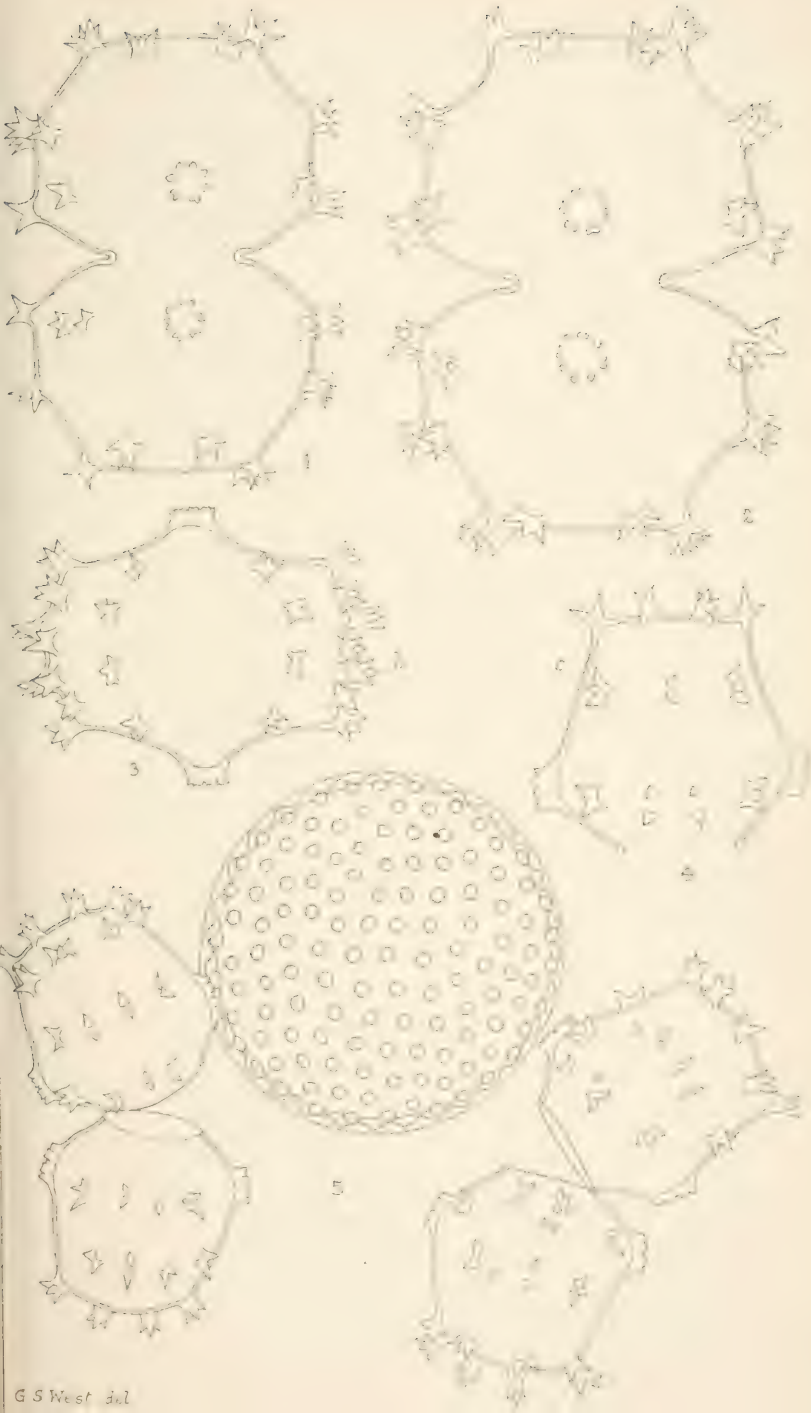

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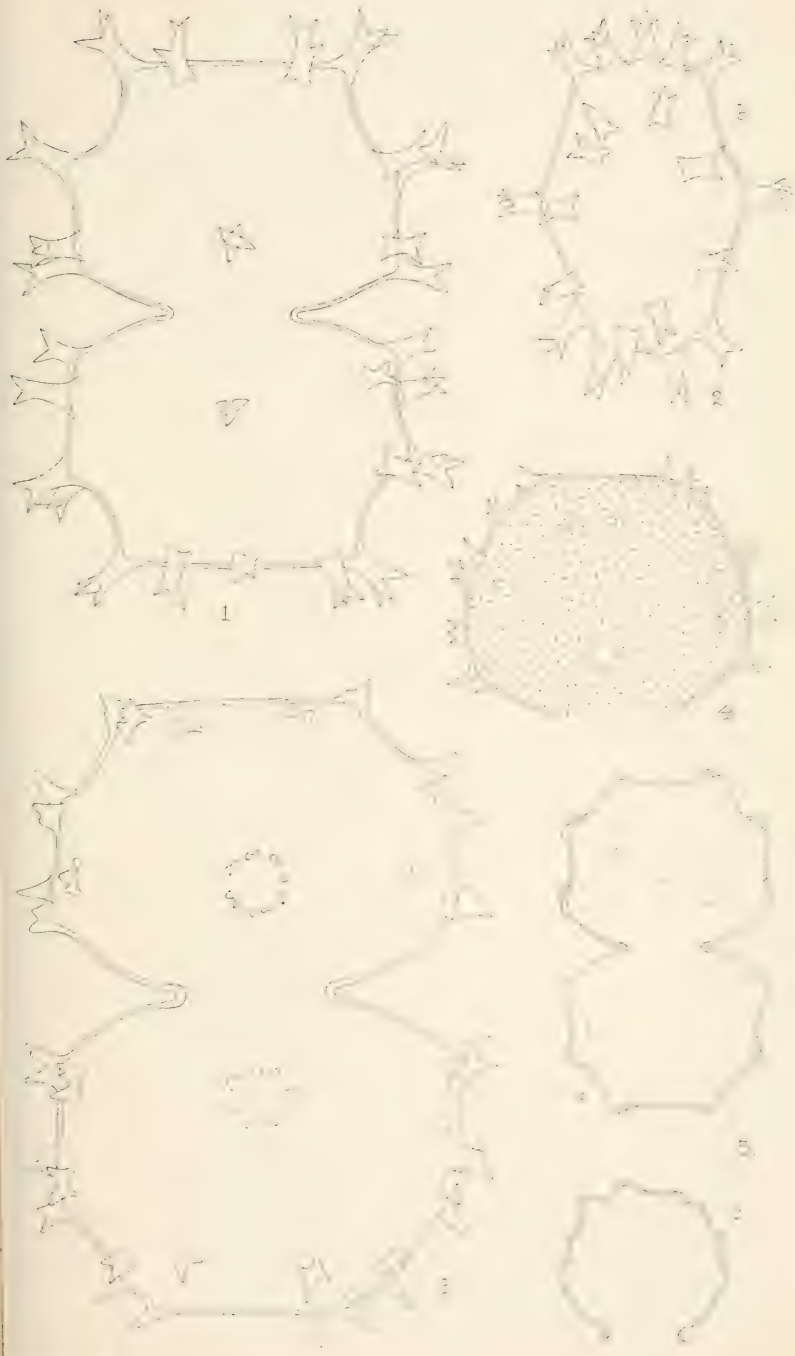

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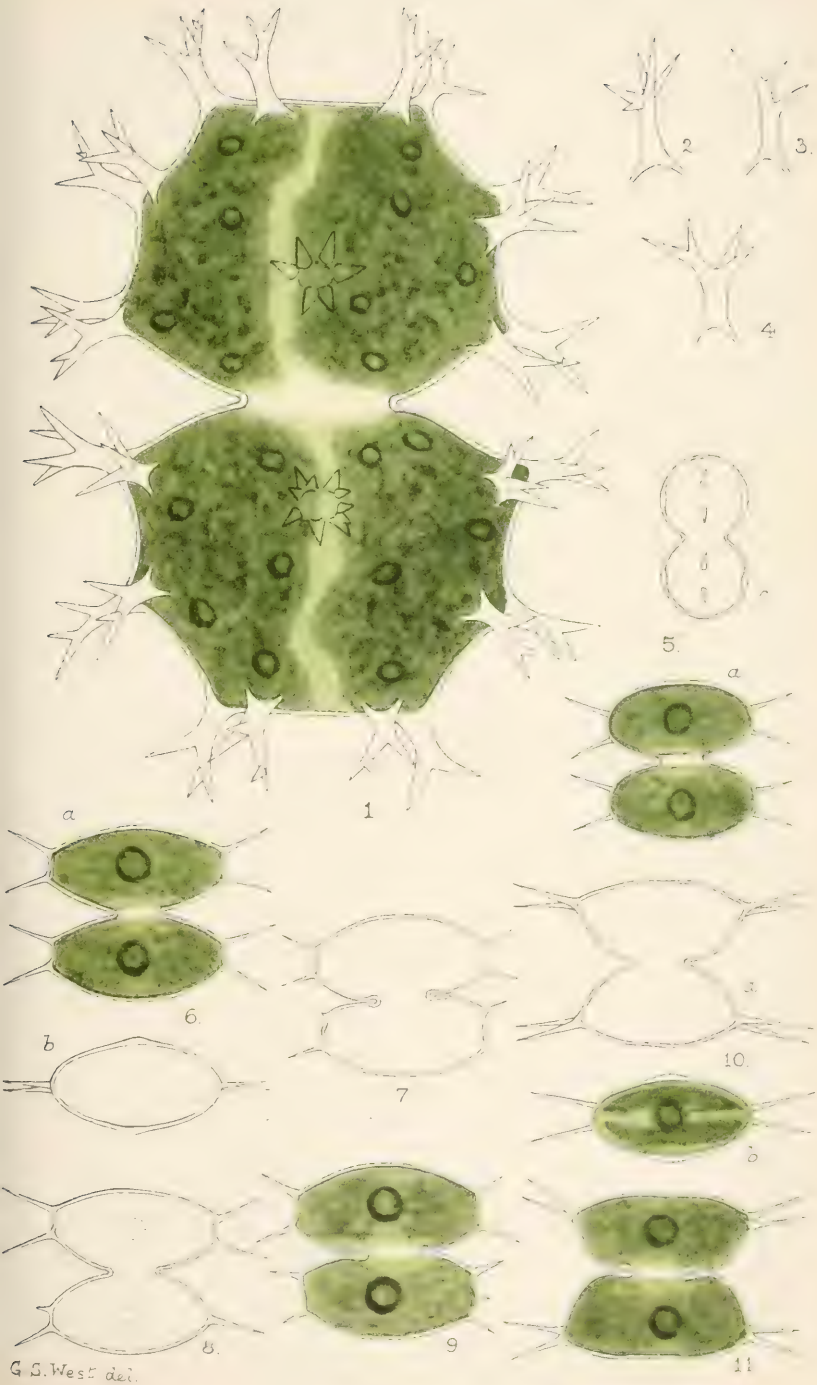

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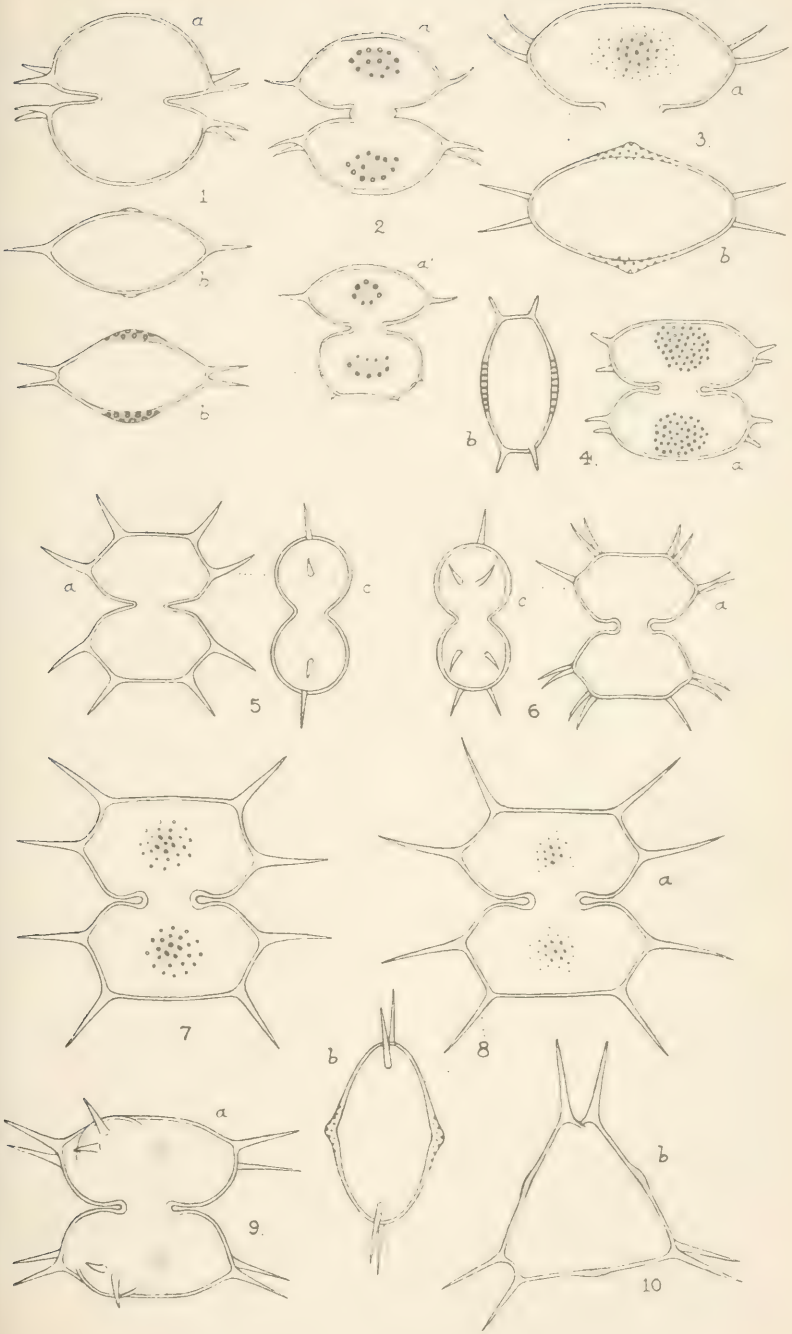

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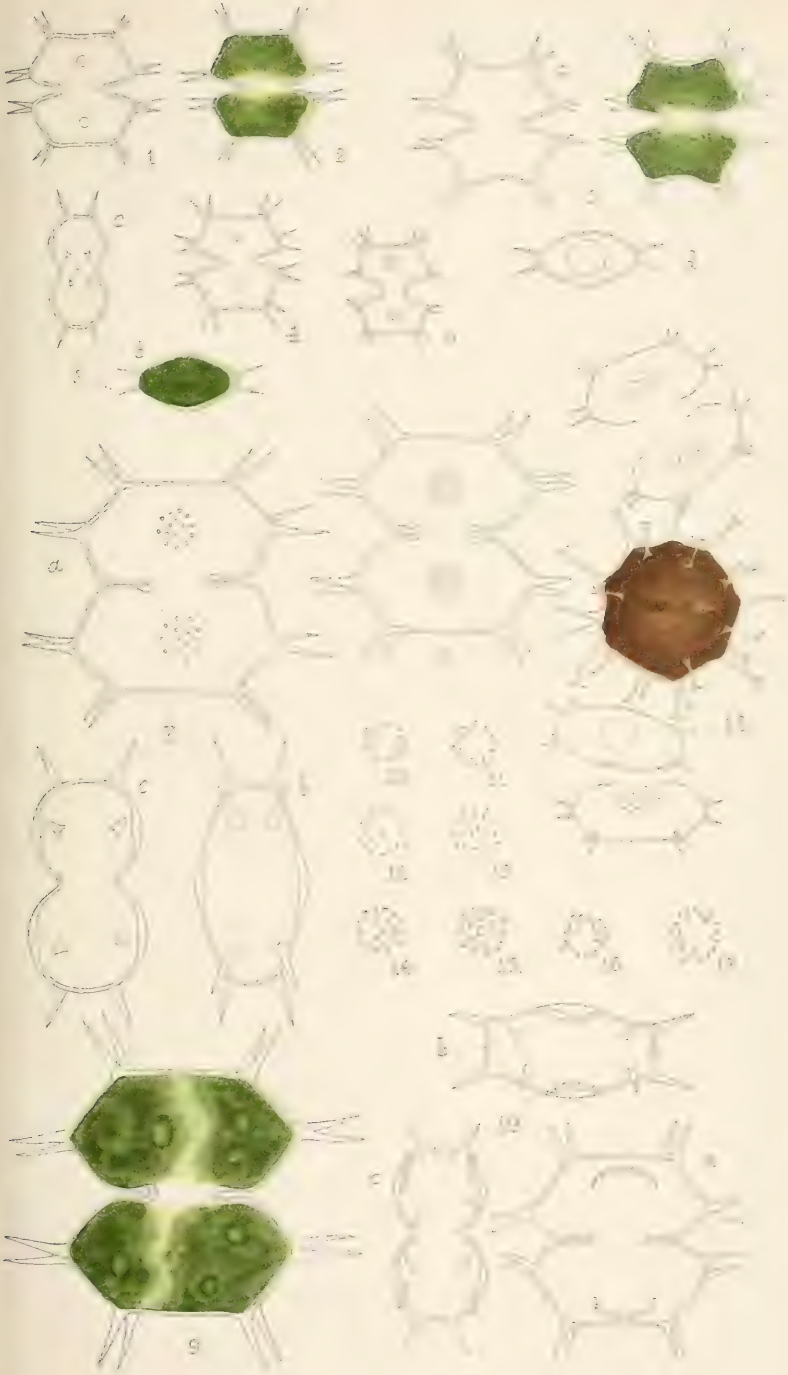

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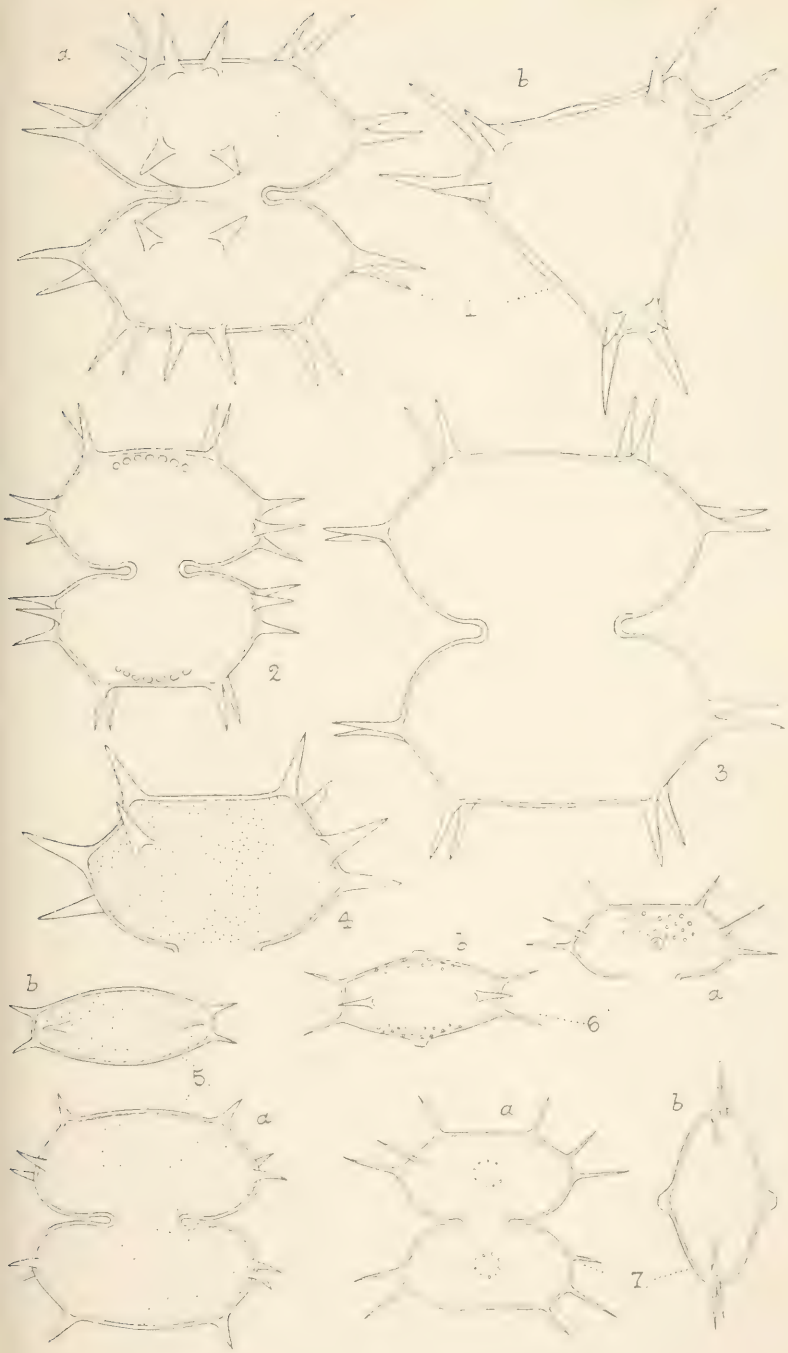

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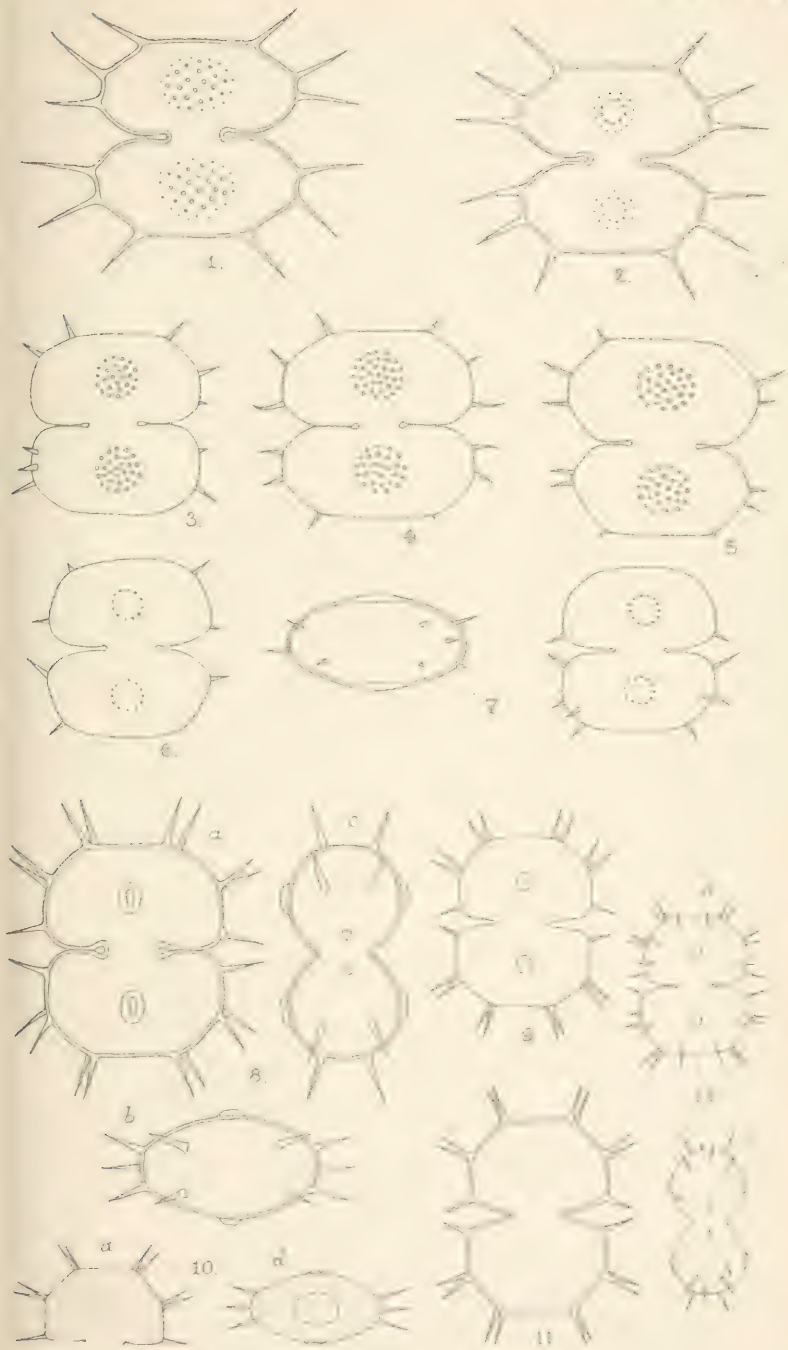

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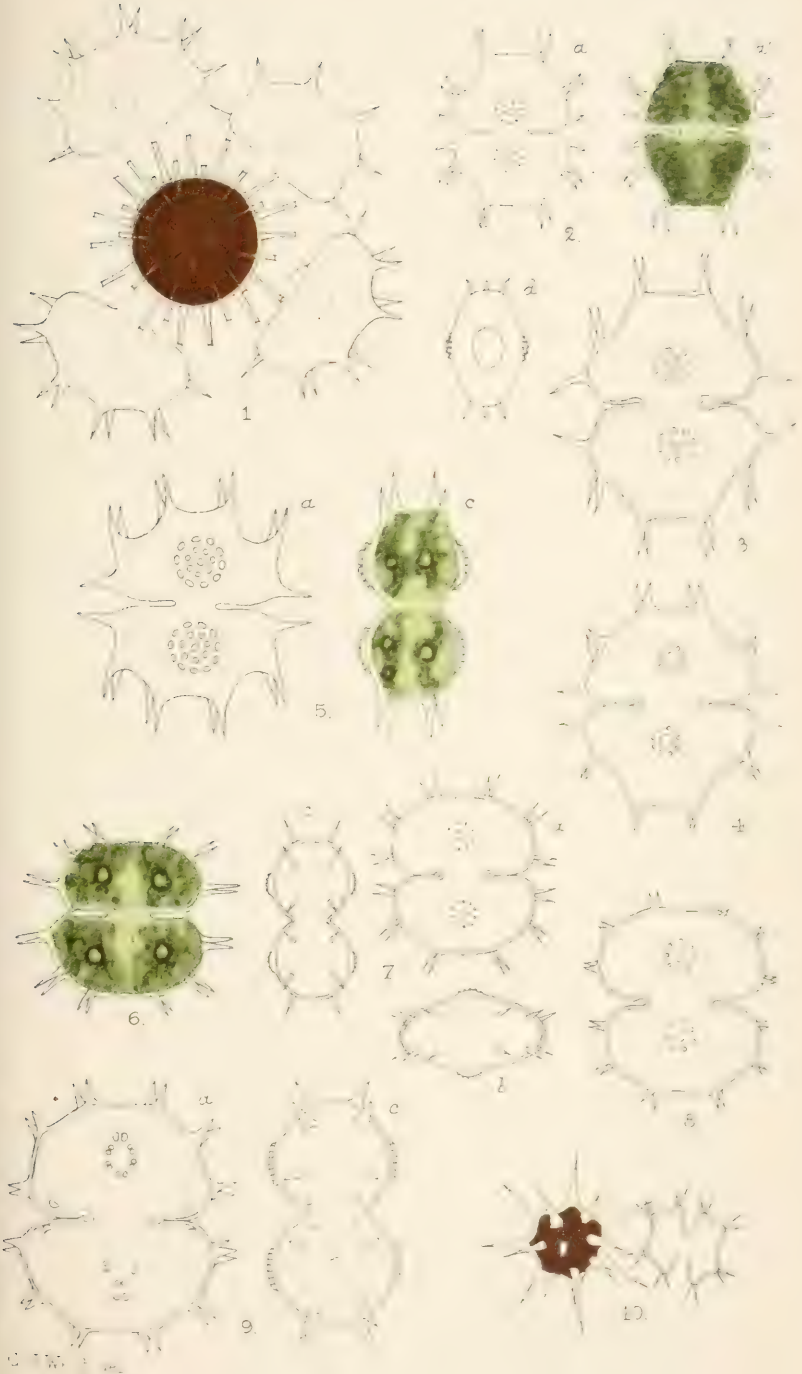
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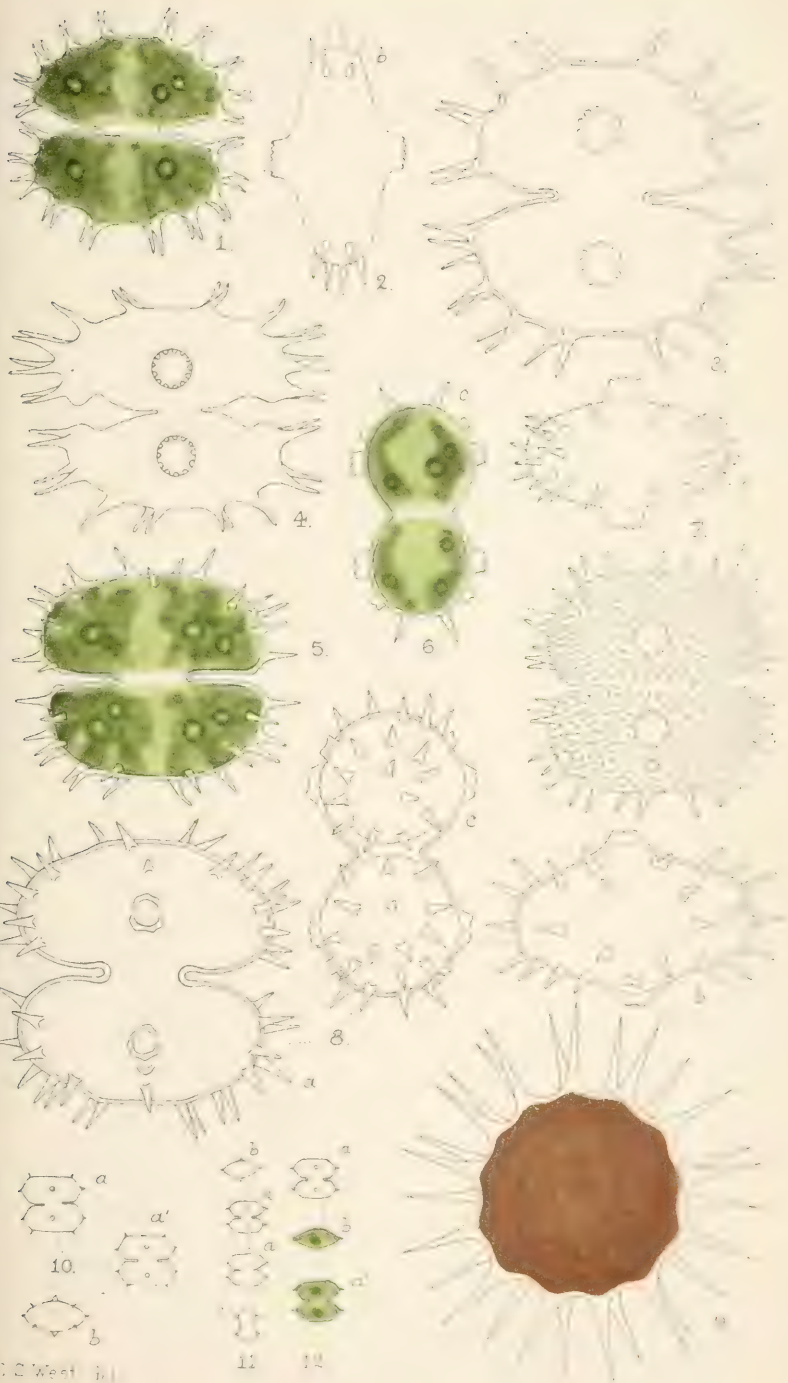
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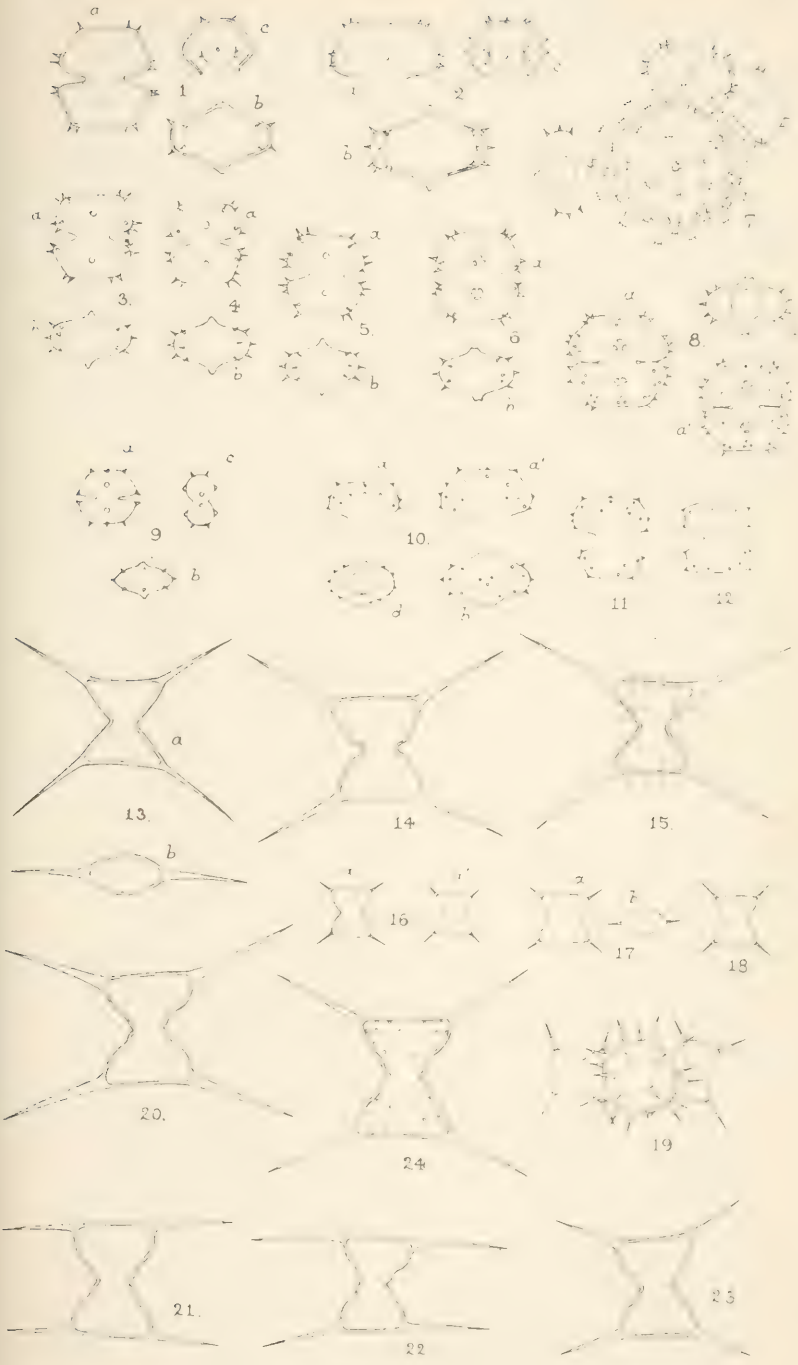

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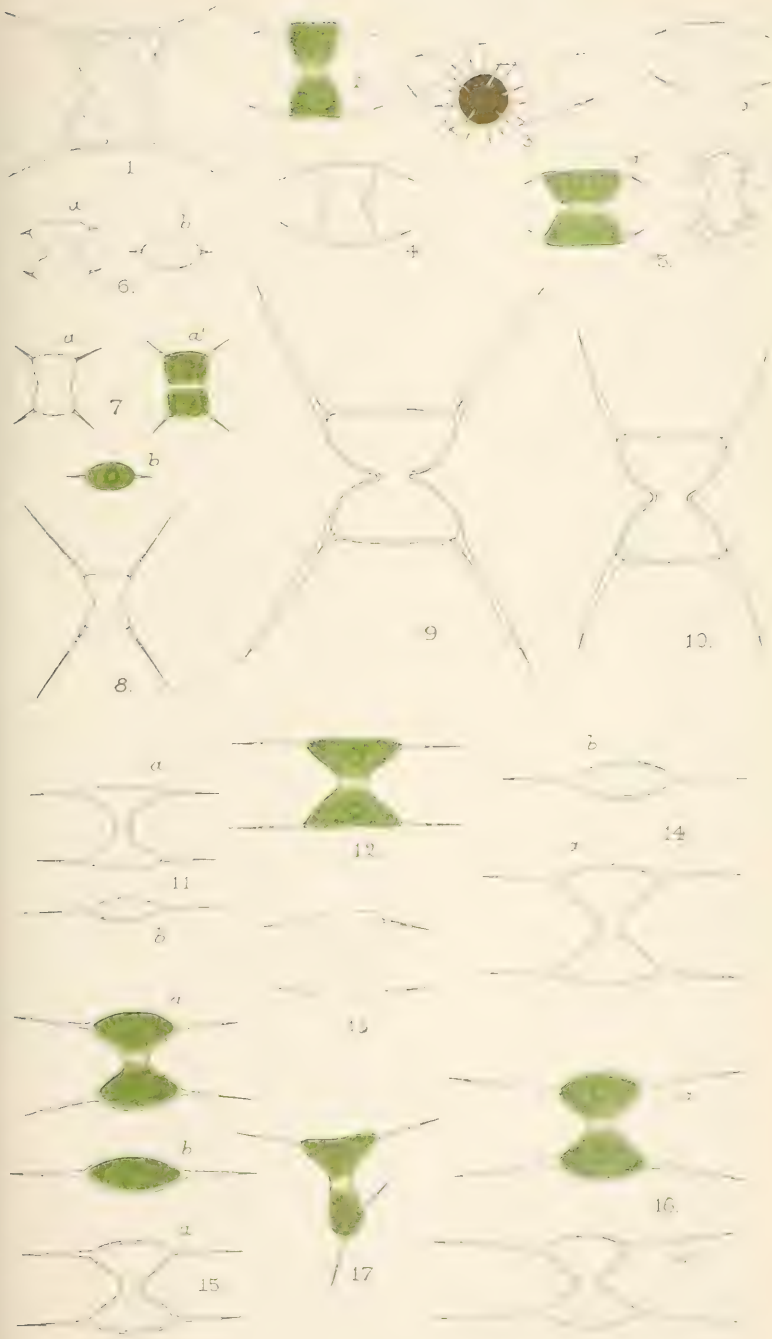
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PLATE CXV.

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PLATE CXVI.

FIGS. PAGE

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4–13.—*A. convergens* Ehrenb. 4, × 360 (after Ralfs); 5, × 520; 6, large form, × 500; 7 and 8, forms in which one semicell is destitute of the spines, × 520; 9, division of preceding form, showing the acquirement of fully developed spines by the new half-cells, × 520; 10, form produced by rapid division and entirely destitute of spines, × 520; 11, division of such a form showing fully developed spines re-acquired by the new semicells, × 520; 12, × 520; 13, zygospore, × 520 . 106

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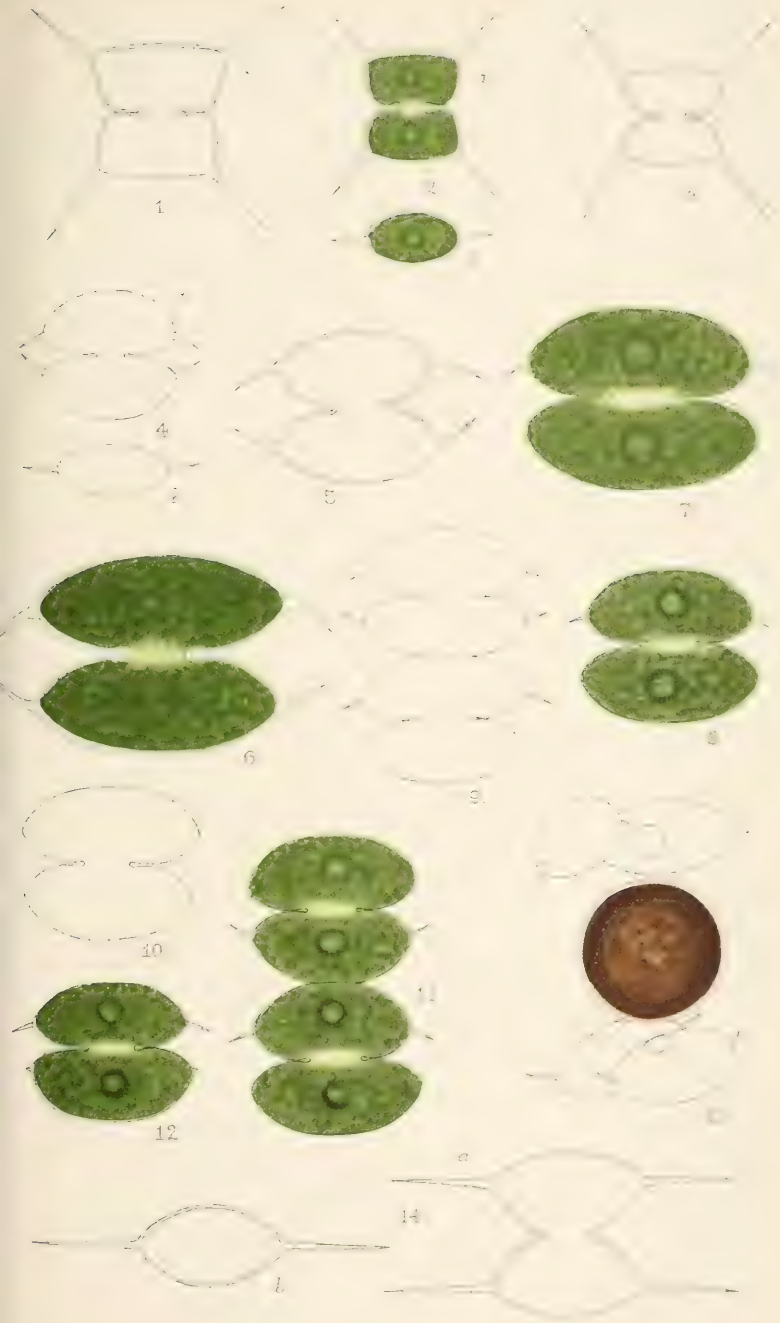
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PLATE CXVIII.

FIGS. PAGE

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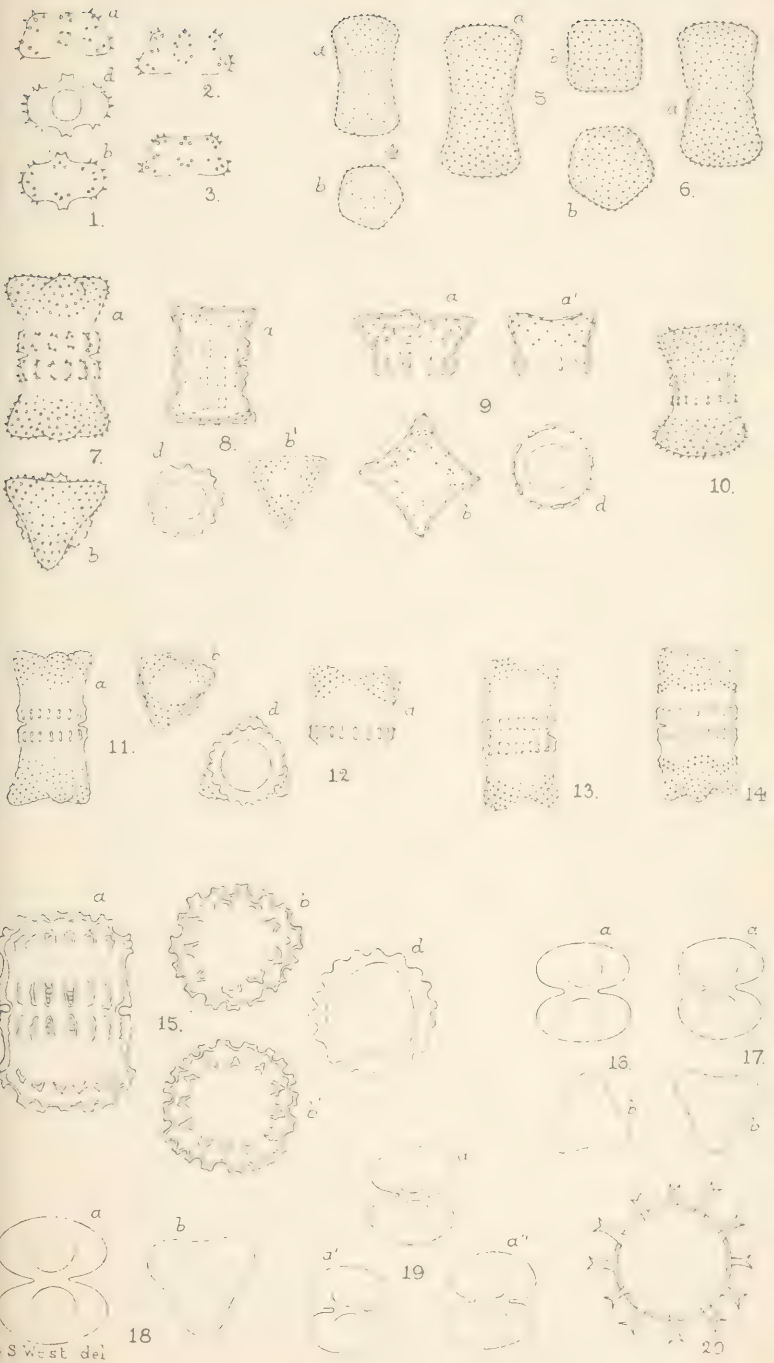
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a''
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PLATE CXIX.

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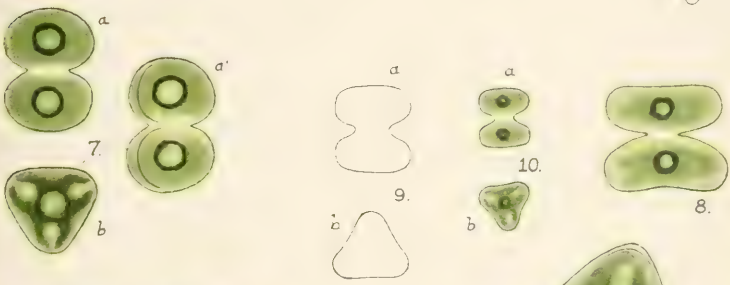

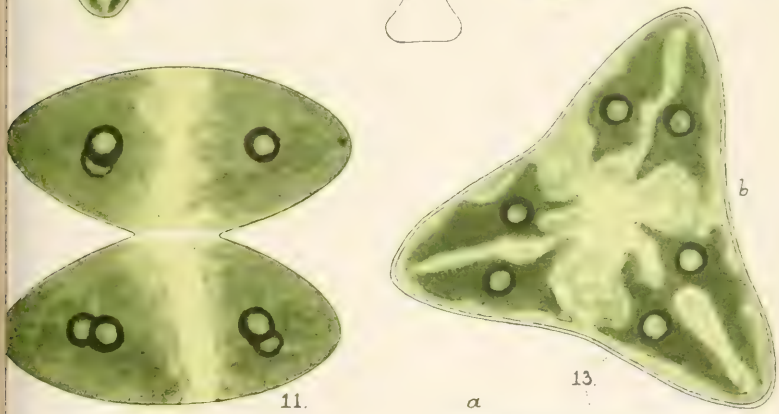

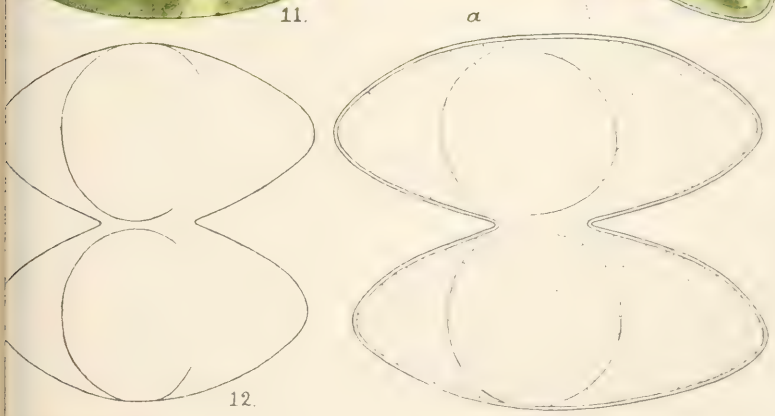

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FIGS. PAGE

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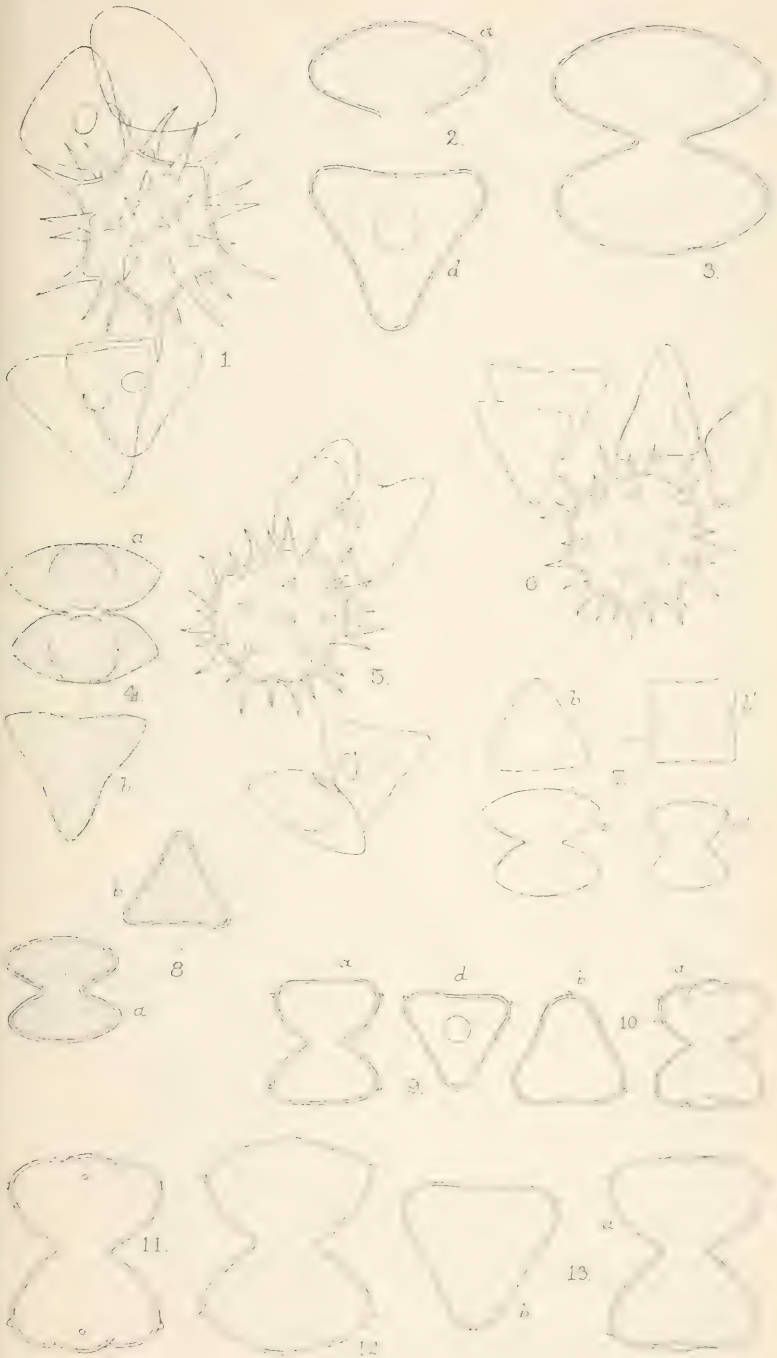

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PLATE CXXI.

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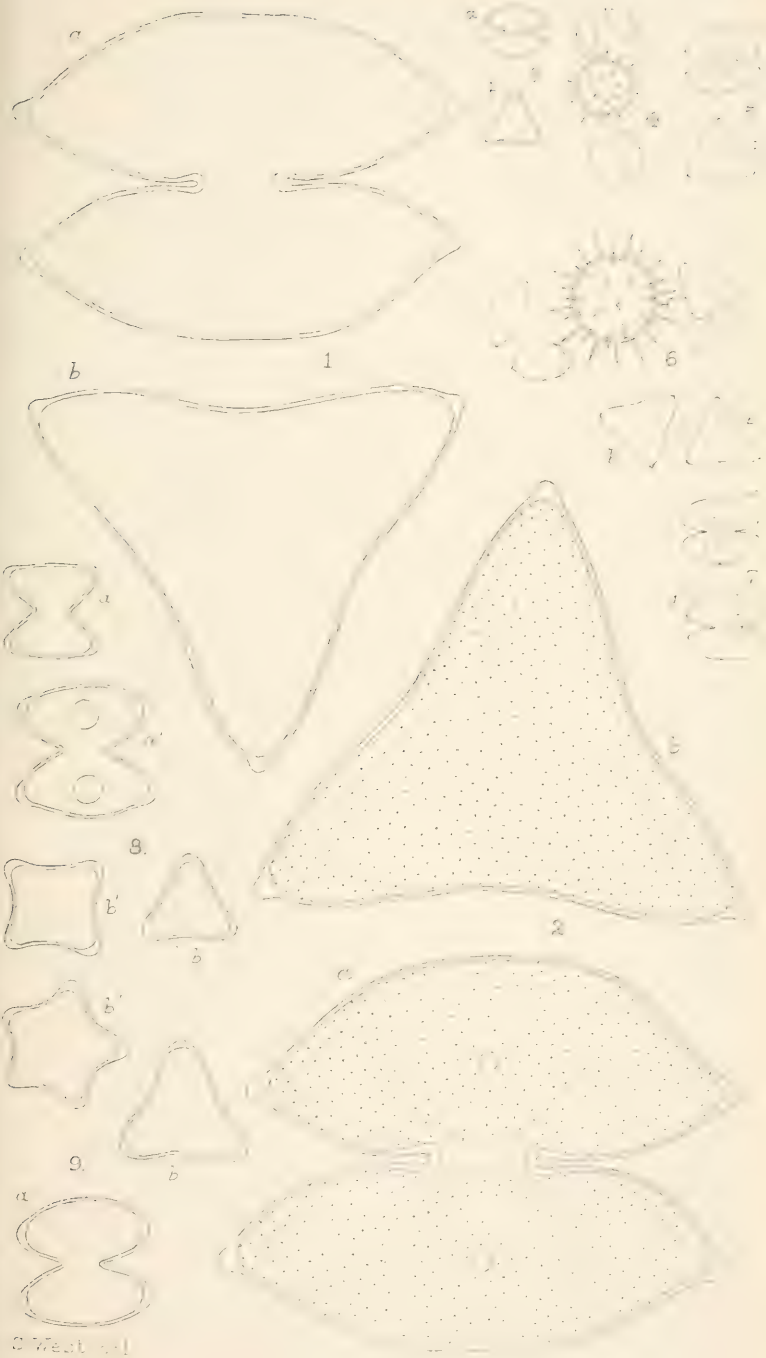

C. C. West & Co.

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PLATE CXXII.

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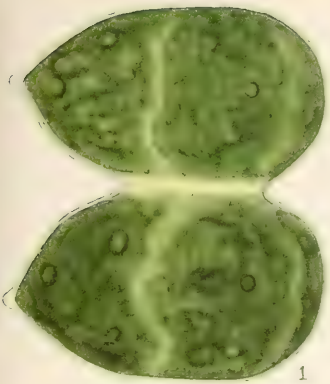
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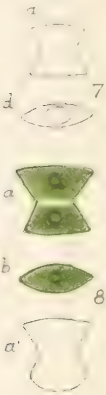

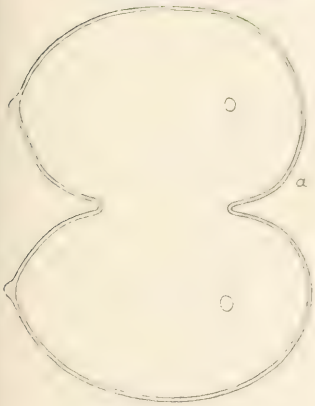

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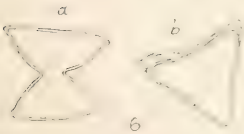

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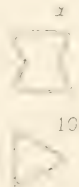

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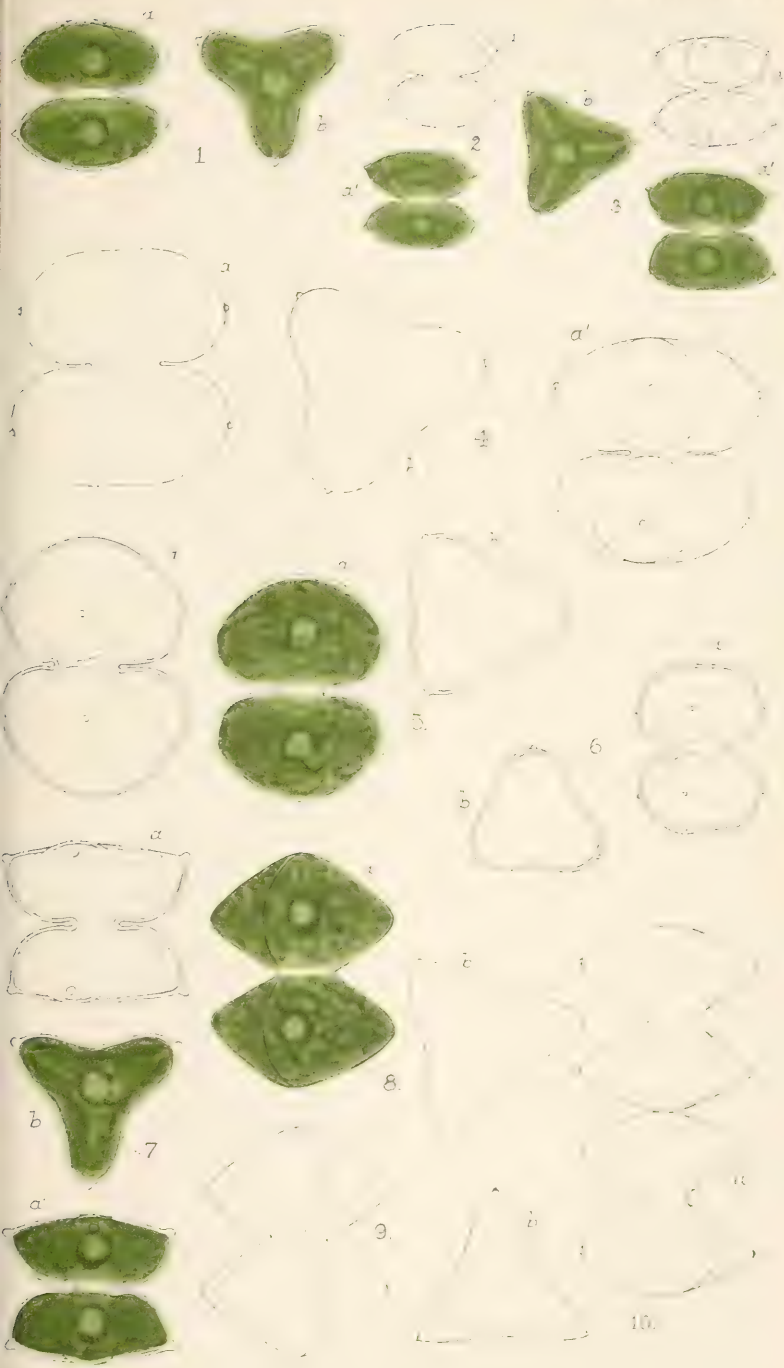

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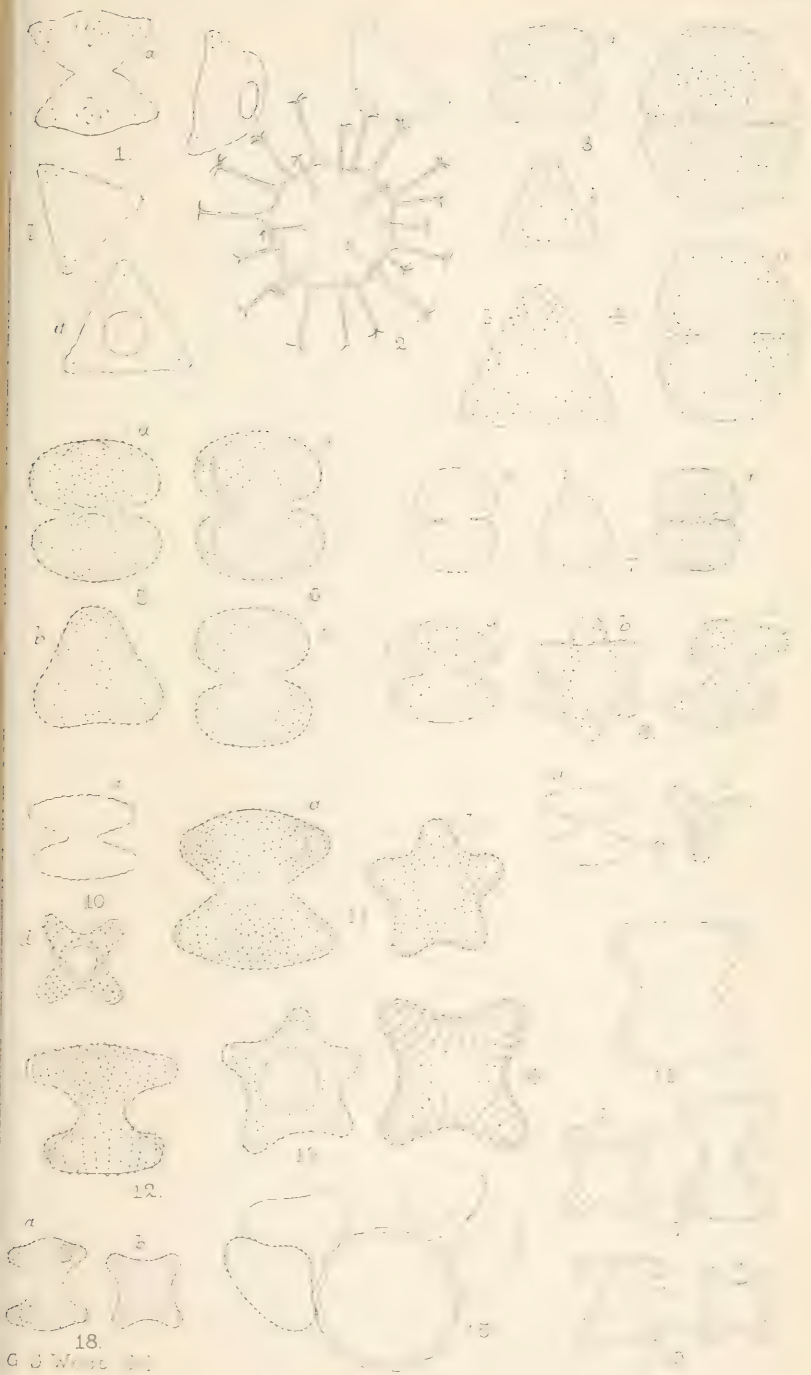
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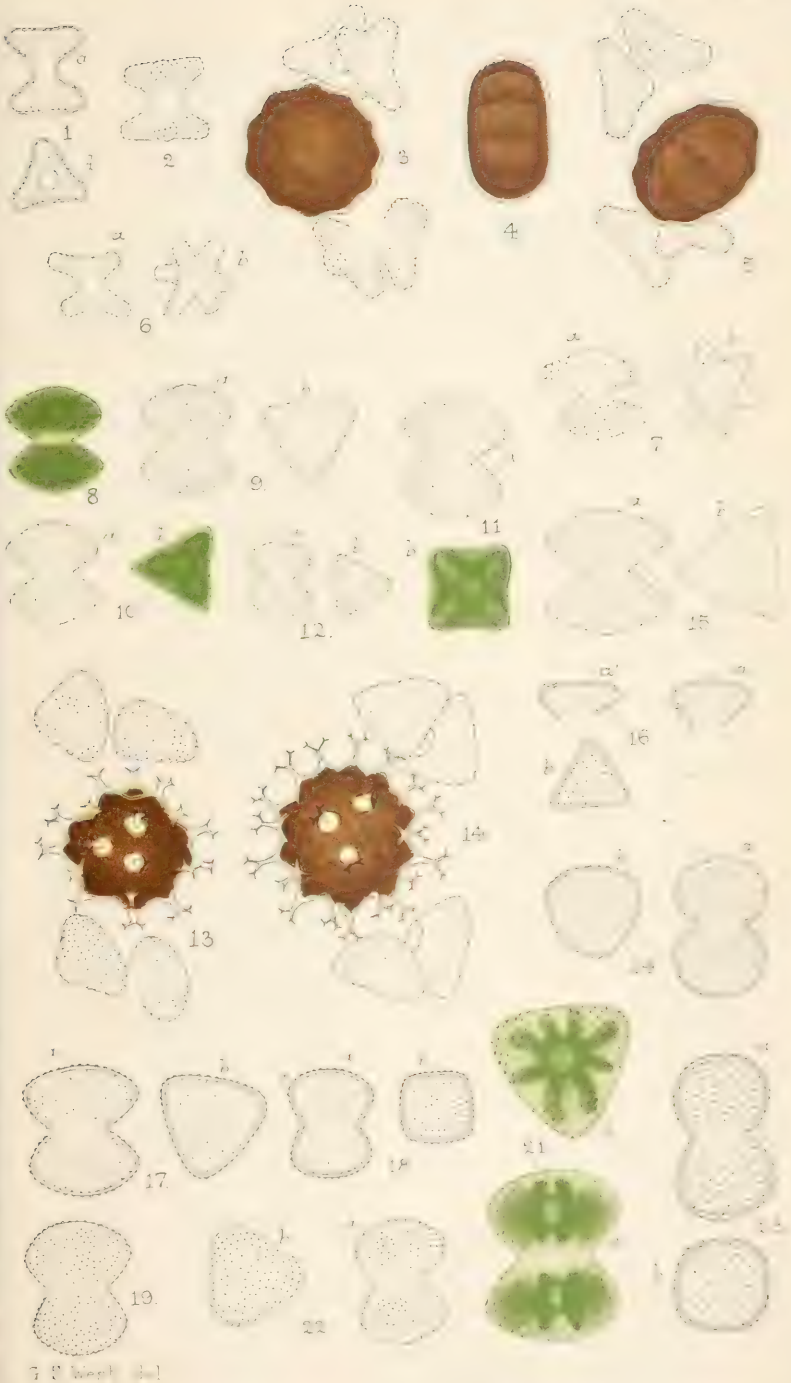

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